THIRD SERIES VOL 61 NUMBER 11 SEPTEMBER 1954

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View in Amsterdam. From a watercolour by Frank Hoar [F]


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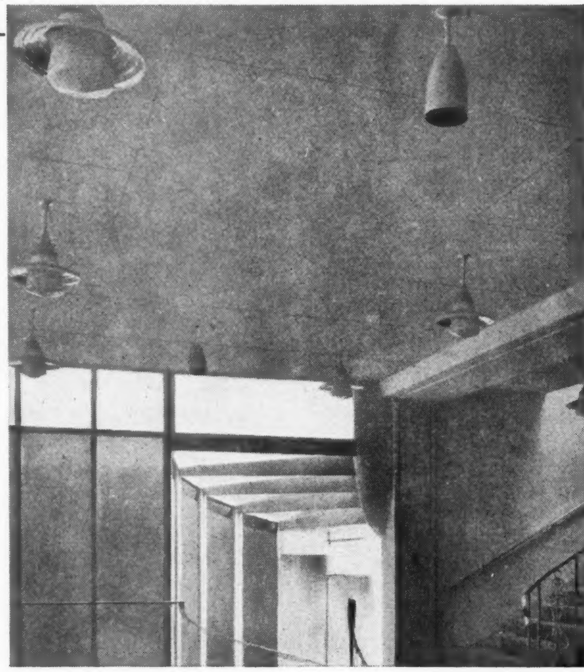

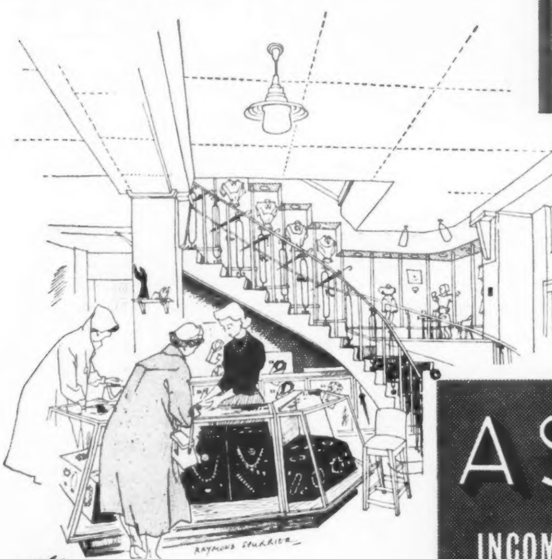

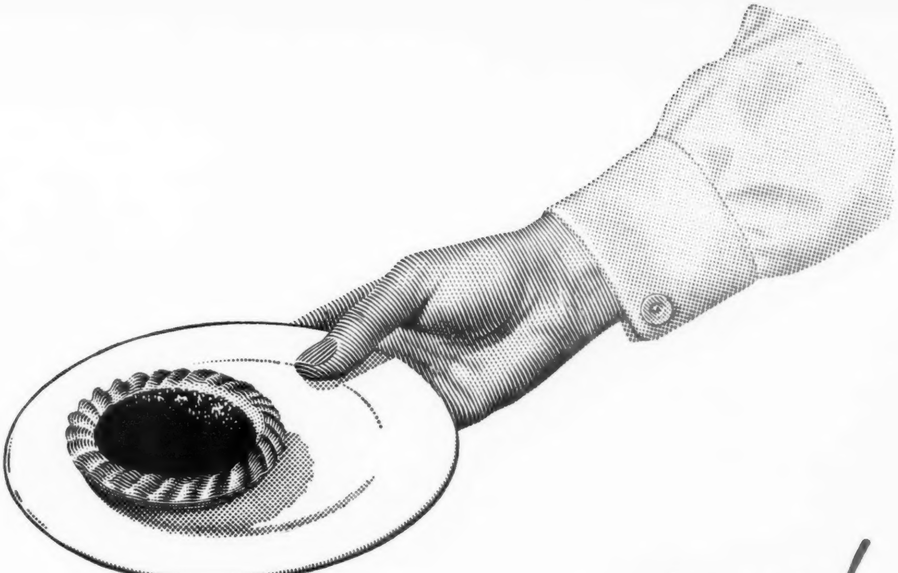

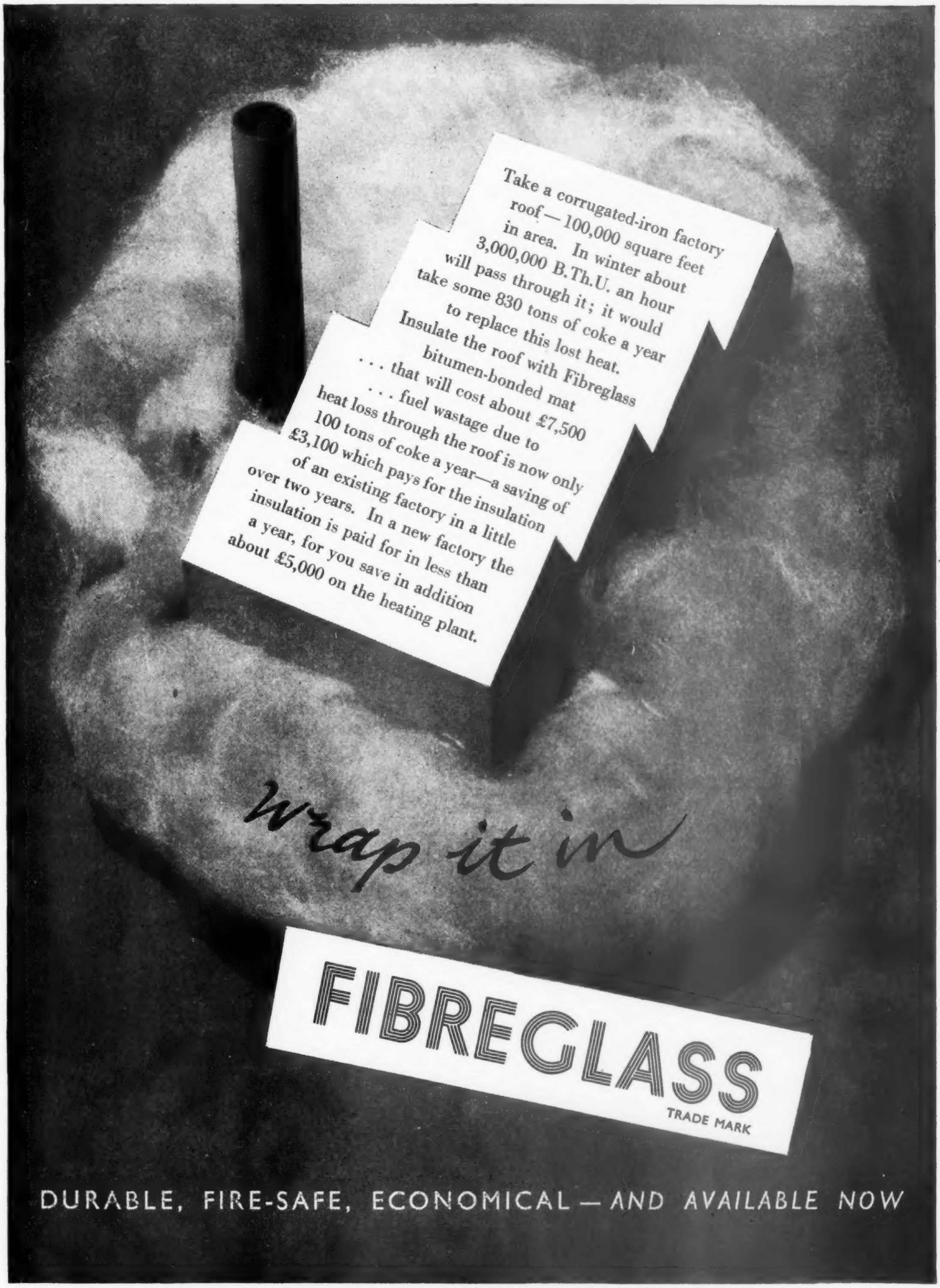
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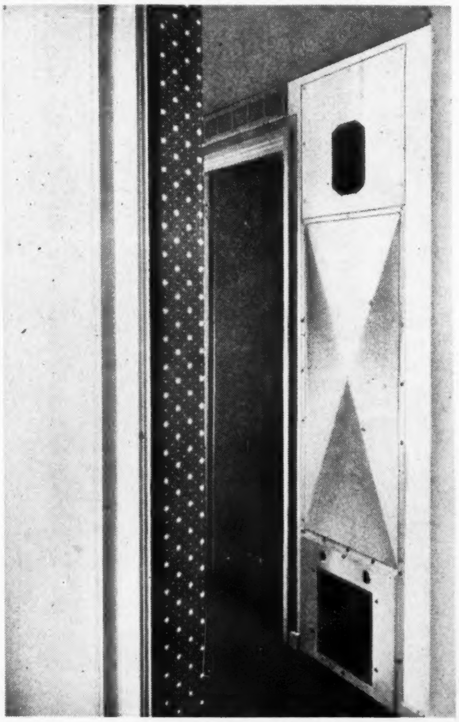

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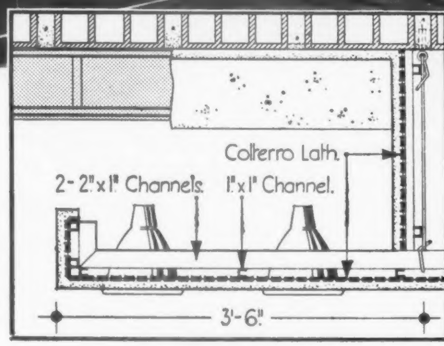

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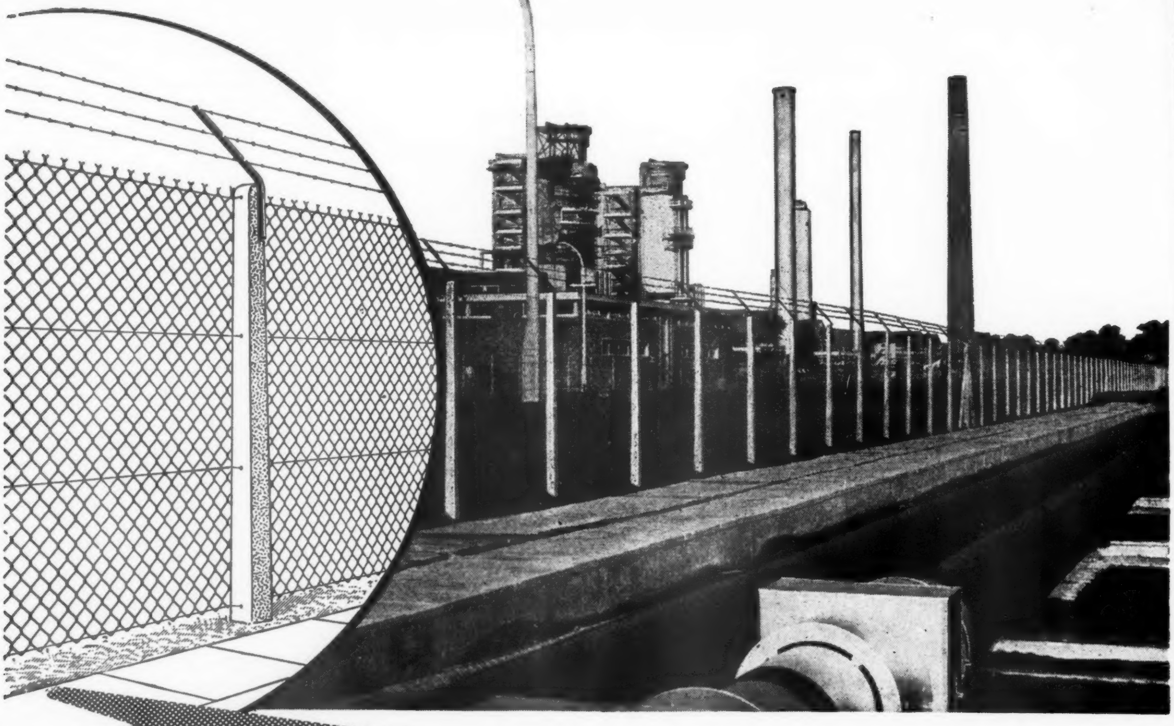

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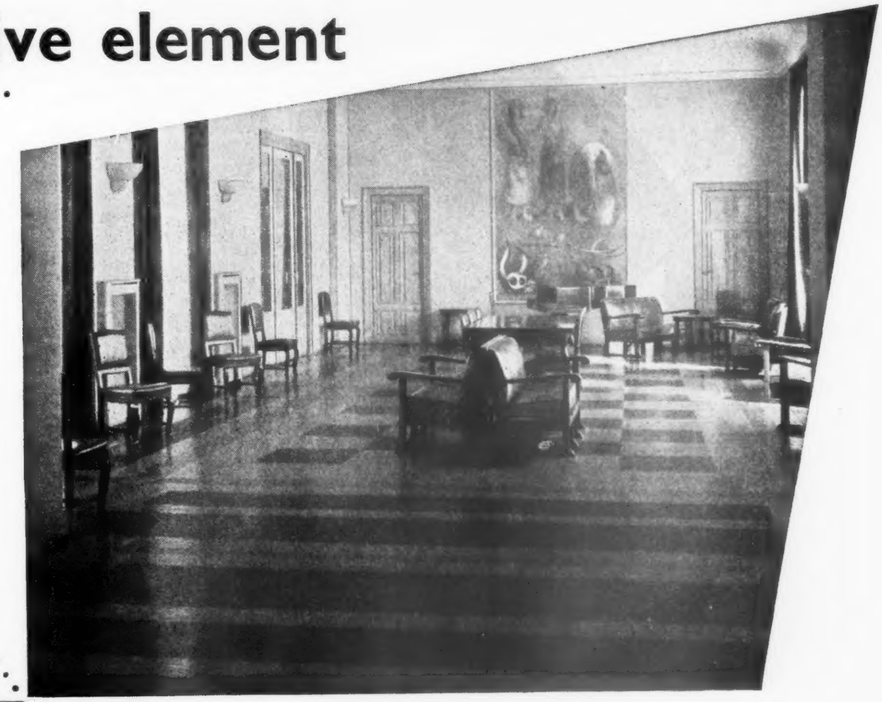

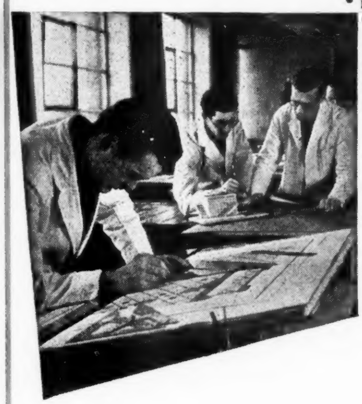

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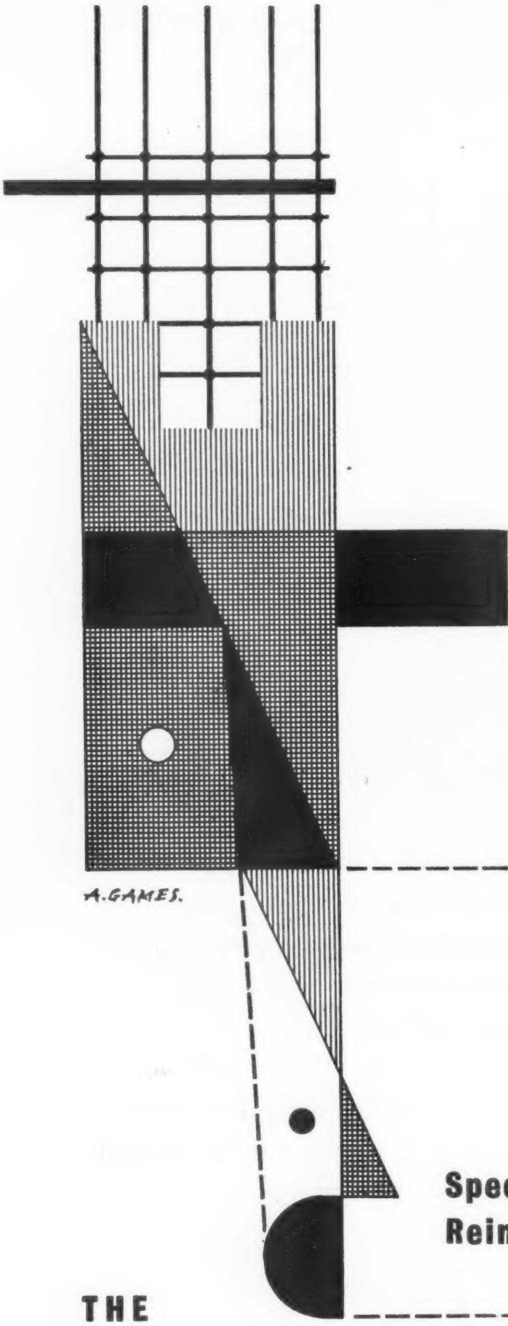

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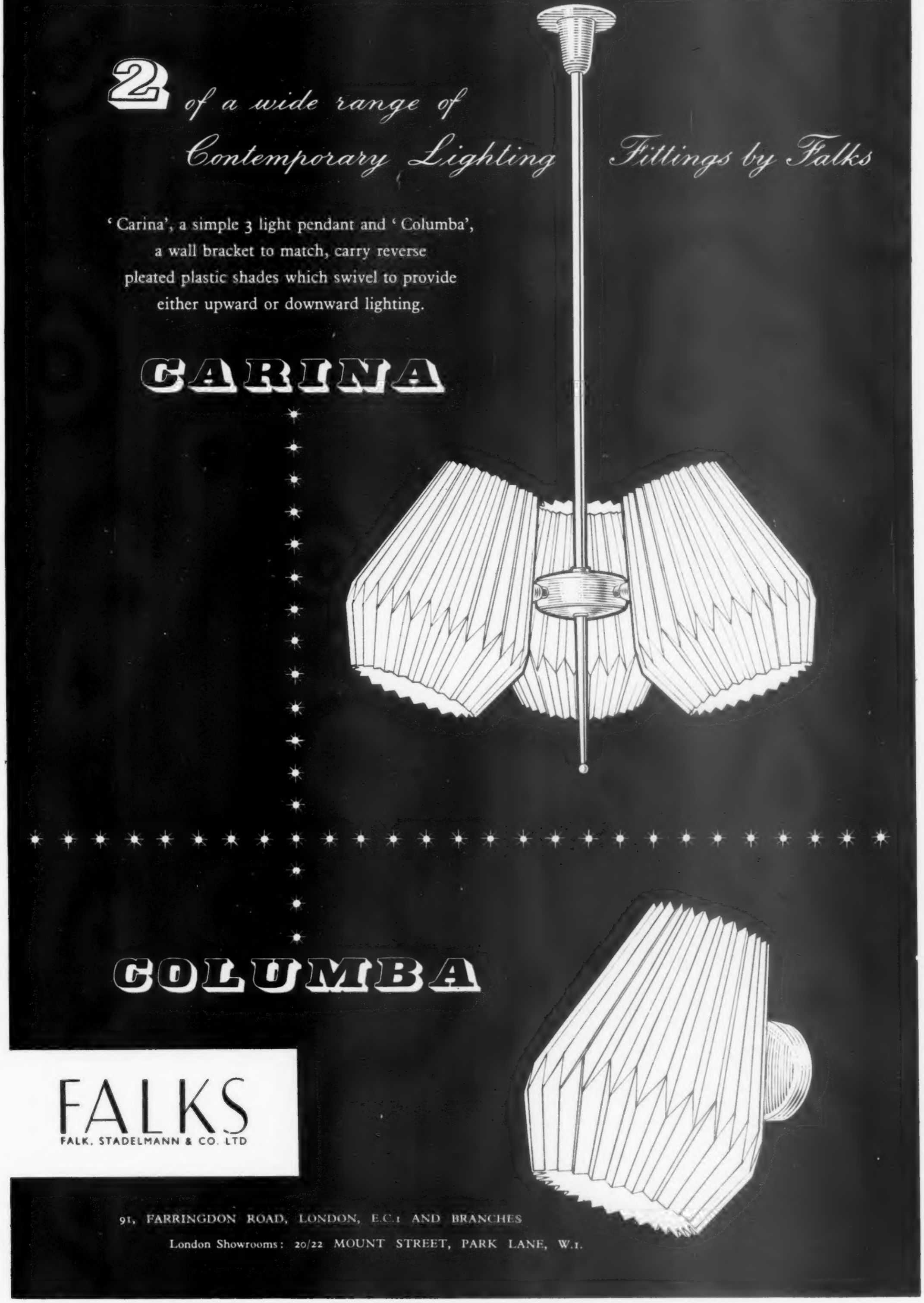
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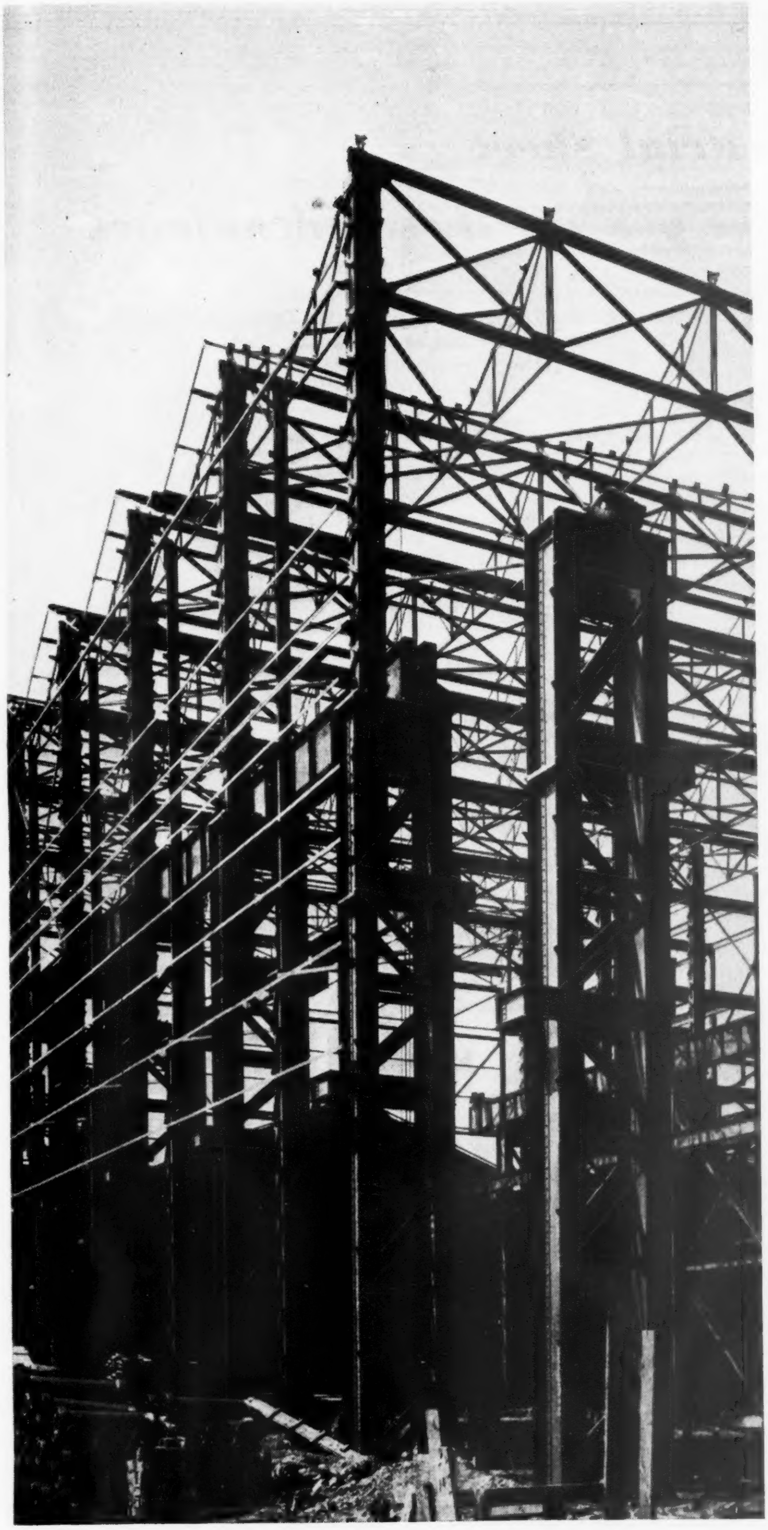

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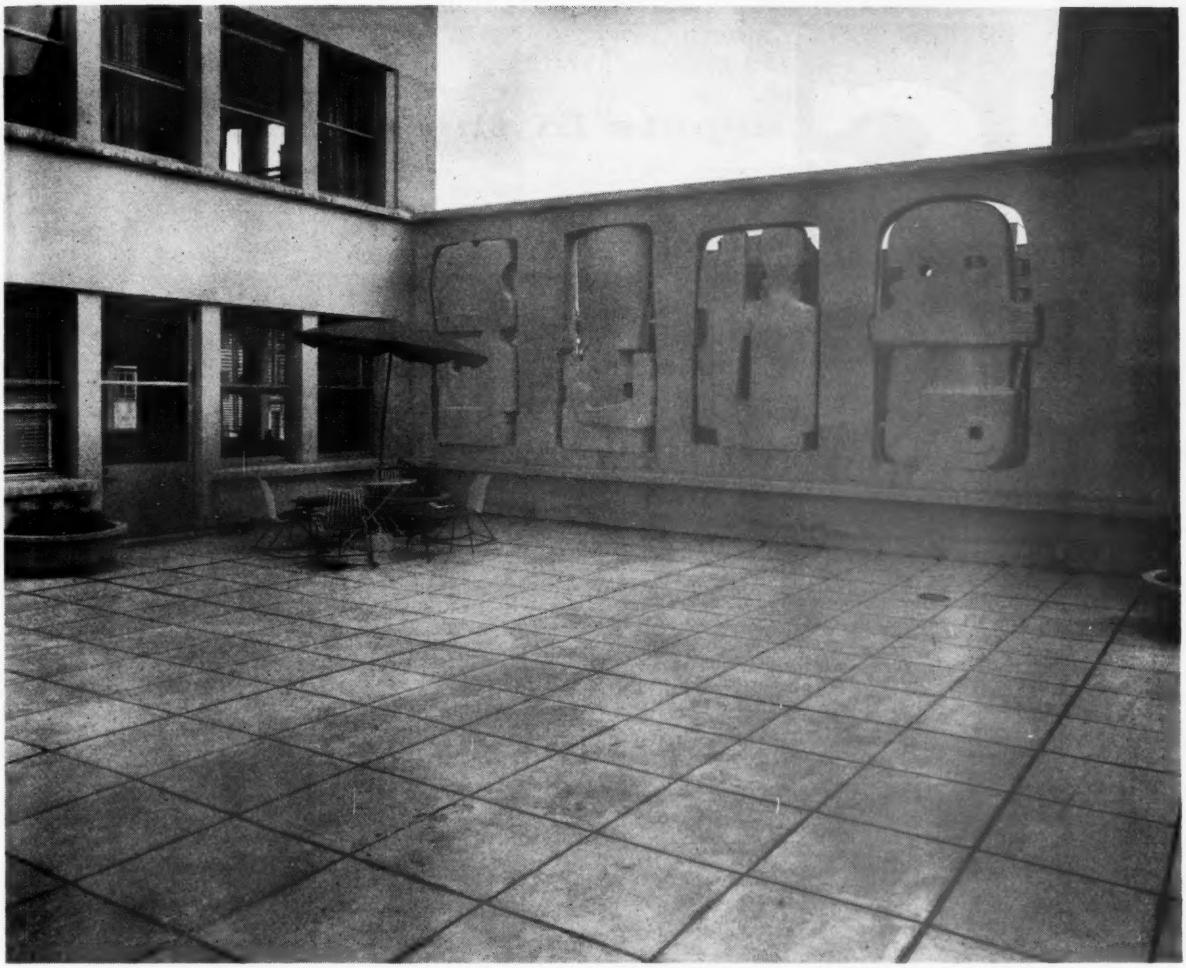

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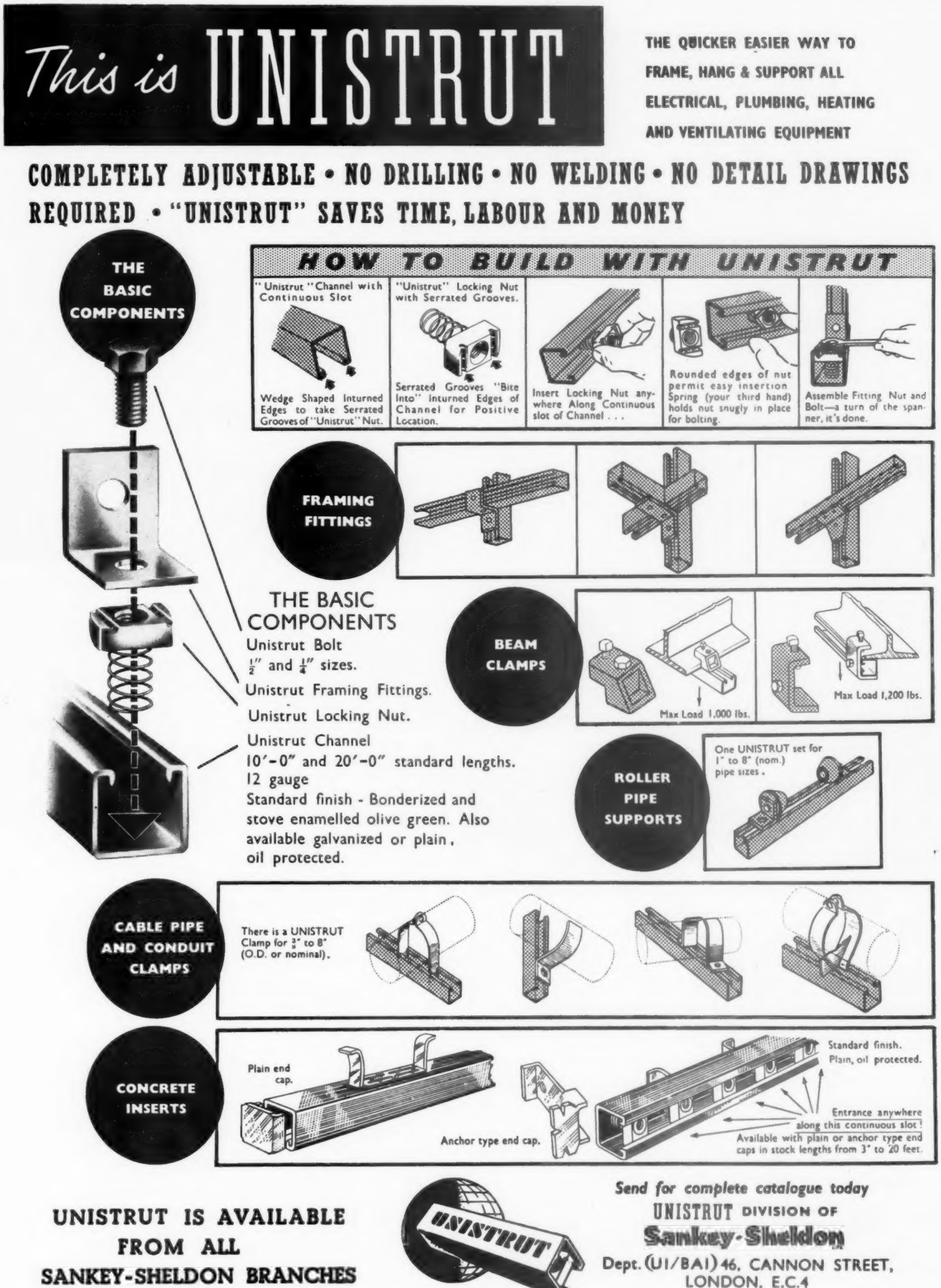
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THE JOURNAL OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS

THIRD SERIES VOLUME SIXTY-ONE NUMBER ELEVEN TWO SHILLINGS AND SIXPENCE
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SEPTEMBER 1954

R.I.B.A. Arrangements for the Session 1954–5

The card listing the general meetings and lectures for the forthcoming session is being sent to members with their copies of the Kalendar. The session opens as usual with the meeting on 2 November at which the President, Mr. C. H. Aslin, C.B.E., will deliver his Inaugural Address. At the same meeting the London Architecture Bronze Medal will be presented to Messrs. A. H. Devereux and E. L. W. Davies [FF] in respect of the new out-patients' buildings, St. James's Hospital, Balham. The President will also unveil the portrait of his predecessor, Sir Howard Robertson.

The first sessional paper is to be given on 7 December by Mr. Basil Taylor, Librarian of the Royal College of Art and broadcaster, on *Art History and Contemporary Art*. The second, on 4 January, is to be by Mr. Maxwell Fry, C.B.E. [F] on *Chandigarh: The Capital of the Punjab*. Mr. Maxwell Fry's account of the planning and building of this new city, on which he has been working with Le Corbusier, is certain to attract a large audience.

The President will deliver his Address to Students on 1 February and present the prizes and studentships. The criticism of work will be given by Mr. Raymond C. Erith [F].

On 1 March Dr. J. Bronowski, philosopher, broadcaster and Director of the Central Research Establishment of the National Coal Board, is to read a paper on *Architecture as a Science and Architecture as an Art*. Royal Gold Medal "night" is 5 April and on 3 May the Annual General Meeting is to be held.

A paper by Professor Sir William Holford [F] on 17 May is concerned with a field of architecture now beginning to expand. Its subject is *Conditions of Building in City Centres*. On 14 June Professor Charles Madge is to read his paper *Sociology and Architecture* which was postponed from the last session.

During recent years the Science Lectures have tended to change in form. This year is no exception. On 25 January there will be a joint meeting with the Illuminating Engineering Society at which the Assessors will criticise entries submitted for the Dow Prize competition. On 15 February there is to be a Symposium on High Flats, details of which will be announced later. On 22 March Professor W. Fisher Cassie of Durham University, King's College Department of Civil Engineering, Newcastle upon Tyne, will lecture on *Comparisons in Modern Structural Steelwork*.

Another Distinction for Sir Howard?

'. . . Sir Howard Robertson, founder of the Royal Institute of British Architects in 1953–4 . . .'—STAFFORDSHIRE EVENING SENTINEL.

Forthcoming R.I.B.A. Exhibitions

The second touring exhibition in the series 'The Architect and You' is now in an advanced stage of preparation and is expected to start its tour in November. Like the first in this series, 'Home and Surroundings,' which is still having a most successful tour, it will consist of two identical copies. It is entitled 'Your House' and, as its name implies, will deal with the planning, design and equipment of the individual home.

The tour of 'Home and Surroundings' is expected to end in the spring of 1955. At present one copy is in Scotland and the other in the West of England. So far they have been shown at 51 centres and seen by 46,000 persons in the 18 months of their tour.

Members are also reminded that the exhibition 'Building in Concrete' will be open at the R.I.B.A. from 21 to 30 October.

C.P.R.E. Conference

The Fifteenth National Conference of the Council for the Preservation of Rural England is to be held at Shanklin, Isle of Wight, from 7 to 9 October inclusive. It will be opened by Lord Mottistone, D.L., F.S.A. [F], who is the President of the Isle of Wight Branch of the C.P.R.E., and will begin with a reception on 7 October at 8 p.m. Papers to be discussed next day are on *Planning Problems in a Seaside County* and *Building in the Countryside* and in the evening there will be an informal discussion. On 8 October, a paper on methods of *Refuse Disposal in Town and Country* will be discussed and there will be a coach tour of the island, tea being taken at Mottistone, by invitation of Lord Mottistone.

Application to attend should be made to the Secretary, C.P.R.E., 4 Hobart Place, S.W.1. The Conference fee is 15*s.* per person (10*s.* if an individual subscriber) plus 8*s.* 6*d.* for the coach tour.

Architectural Lectures at Crosby Hall

Mr. Robert Furneaux Jordan [F] is to give a series of six lectures at Crosby Hall, Chelsea, under the aegis of the Chelsea Society, during the autumn. The dates and subjects are: 28 October, *Romanticism, the Picturesque and the Gothic Revival*; 4 November, *The Railway Age*; 11 November, *The Crystal Palace*; 16 November, *William Morris and the Pre-Raphaelites*; 25 November, *Pioneers of the Modern Movement*; 2 December, *Today and the Future*. Tickets, price 2*s.* per lecture or 9*s.* for the course of six, can be obtained at the door or from the Hon. Secretary, The Chelsea Society, 8 King St., St. James's, S.W.1. The lectures take place at 8.15 p.m.

Royal National Eisteddfod of Wales, 1955

The presentation of a Gold Medal for Architecture is a new departure at the National Eisteddfod. It will not be offered as a prize for competition in an architectural subject, but will be awarded periodically by the Council, on the recommendation of professional assessors, to the architects of buildings of distinction which have been erected in Wales. The award is intended to honour those who in this way have made a real contribution to the architecture of the Principality. Nominations will not be confined to large or imposing buildings, but will extend to the smaller or less ambitious which may have an equally valuable contribution to make. Entries can include either individual buildings or a group of them within a scheme designed by one architect or partnership. In the latter case, layout and appropriate siting will be factors to be taken into consideration.

The Court of the National Eisteddfod have appointed the following as judges to advise them on the award of the medal: Mr. Lewis John, M.A., B.Arch.(L'pool) [*F*], and Dr. T. Alwyn Lloyd, LL.D., J.P., P.P.T.P.I. [*F*].

The procedure to be followed for nomination is that the architect concerned, or some other individual, organisation, or public body, will send to the Eisteddfod Office, Pwllheli, by 1 May 1955, particulars of the building or group (with the architect's name), erected within a given period, to which attention by the judges is desired. Entries should be accompanied by two or three good photographs of the building. Entries will not be restricted to any particular locality.

Prizes in three architectural competitions are also offered in the 1955 National Eisteddfod. They are £50 for the design of a health centre for Pwllheli and District, £30 for the redevelopment of any Caernarvonshire village with a population between 1,500 and 3,000 and, for juniors only, £20 for a Library for Pwllheli. Intending competitors should send their names to the General Secretary, Eisteddfod Office, Pwllheli, so that conditions and details can be sent them.

Housing Progress

In the August JOURNAL we quoted from the FINANCIAL TIMES some figures of house production and an editorial commentary on them. In a recent issue THE FINANCIAL TIMES gives later figures which show that the expected total of 350,000 new houses will almost certainly be achieved, almost 200,000 houses having been built in the first seven months of 1954. In spite of the wettest summer for years, post-war housing records have been broken during the last three months, 30,159 permanent houses having been finished in July—some 3,000 more than in July 1953. This increase is almost all private building, the output of local authority houses being about the same as last year.

Output of the main building materials is keeping pace with the increase in new construction. Brick production is expected to reach 7,500 m. this year, with the pre-war output of 8,000 m. within reach next year. Cement production has risen by an extra half-million tons to more than 6·2 m. in the first 33 weeks of 1954. This increased output is being fully absorbed by new building in factories, shops and offices and a considerable quantity of materials, particularly cement, is being used by the U.S. authorities on their bases in this country.

Post-Graduate Fellowship in the United States

A King George VI Memorial Fellowship for post-graduate study and research in industrial architecture at the Carnegie Institute of Technology, Pittsburg, has been awarded to Mr. P. E. Williams [*A*]. This is the first time that this Fellowship, which is sponsored by the English-Speaking Union of the United States, has been awarded. Mr. Williams was a full-time student of the Brixton School of Building and has recently been working in the Housing Division of the London County Council.

Training Courses in Concrete Practice

Except for unimportant work, the days have gone by when happy-go-lucky ways of making concrete were used and anything that 'looked right' would do, although even now the experienced eye is not to be despised. Now, if the ingredients of concrete are not to be used wastefully they must be carefully measured and compacted with knowledge and care. The design of reinforced concrete has been developed by research and experiment to such a degree of exactitude that haphazard methods could possibly cause failure.

It is the man on the job who has to translate elaborate and highly technical drawings and details into terms of deposited concrete; for him to understand why certain things should be done is better than a uniform obedience to elaborate instructions which may lead to some being disregarded. It is therefore of interest to learn that the City and Guilds of London Institute are inaugurating the award of an officially-recognised certificate of proficiency for concrete supervisors and foremen. Courses are being organised in technical schools and colleges throughout the country, and are being so arranged that participants can start a course at one college and complete it at another if their work should demand a move during the session.

These courses are designed to 'train a class of men who will not only know how good concrete should be made, but the why and wherefore, and will be able to pass on their knowledge to the men under their supervision. It is an innovation that must benefit both employer and employed.' So far 36 technical colleges have announced their intention of offering the courses.

Single-Stack Plumbing

A full-sized, four-storey installation of single-stack drainage for blocks of flats, which was described in the May JOURNAL, will be put on view in the museum of the Royal Sanitary Institute, 90 Buckingham Palace Road, during November. The structure will be complete with all sanitary fittings, and translucent plastic pipes will enable the system to be seen in action.

Single-stack drainage has been developed by the Building Research Station during the past three years. In a five-storey building it costs £20 per flat as against £41 for a two-pipe system and £34 for a one-pipe system. The London County Council have fitted several installations during the last two years so that single-stack drainage has stood the test of practical experience. This enterprise of the Royal Sanitary Institute will permit architects to see it for themselves.

The National Buildings Record

Mr. C. B. Willcocks [*F*] reproves us for saying in the August JOURNAL that the National Buildings Record was set up 'at the suggestion of the R.I.B.A.' The proposal originated with the Society for the Protection of Ancient Buildings, the part played by the R.I.B.A. being the convening of the inaugural conference on 18 November 1940 and giving the N.B.R. house room for some months until its removal to Oxford.

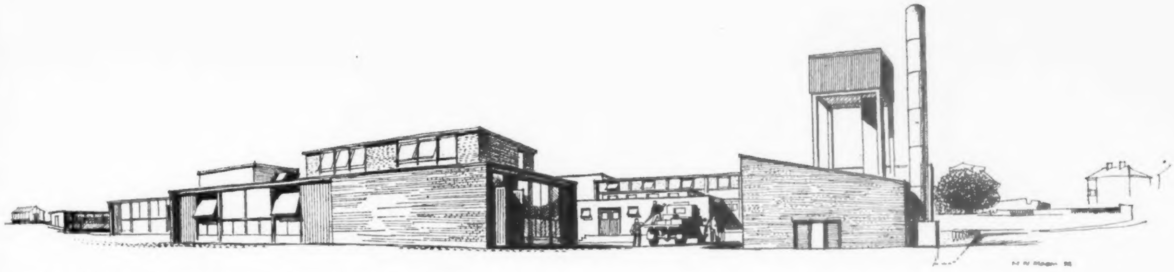
To Lecture in University of North Carolina

Mr. Brian Hackett, M.A. [*A*], has been invited to serve as Visiting Lecturer in the School of Design, University of North Carolina, U.S.A., for the month of February 1955.

R.I.B.A. Diary

THURSDAY 21–FRIDAY 22 OCTOBER. All-day Conference on the Design of Health Buildings. (Tickets 10*s*. each, obtainable in advance from the Secretary, R.I.B.A. See the JOURNAL for July, p. 351.)

THURSDAY 21 OCTOBER–SATURDAY 30 OCTOBER. Exhibition—Building in Concrete. Mon.–Fri. 10 a.m.–7 p.m., Sat. 10 a.m.–5 p.m.



Metalwork block looking north, drawn from viewpoint 2

Cost Analysis of a Secondary Modern School

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EDITOR'S NOTE: *This is an attempt to analyse the cost of a school building according to a system different from and more usable than bills of quantities. It is not intended to supersede bills of quantities, but to give designers an accurate picture of the percentage cost of each item of structure, finish and equipment in a school building which will be of value in future work. Inevitably one building had to be chosen for analysis and, equally inevitably, one building would possess certain features that are not always found in other schools. It happens that the building chosen—Darton Secondary Modern School, near Barnsley, Yorkshire—was designed to resist the effects of mining subsidence, a fact which has affected the figures to some extent, though not the method of analysis. This painstaking piece of research by the County Architect to the West Riding and his staff is well worth detailed study.*

Introduction. The Darton School is a two-form entry secondary modern school for boys sited a few miles north-west of Barnsley in the West Riding of Yorkshire. Tenders were received in October 1953, building started in March this year, and completion is expected within 104 weeks. The design is notable for its economy in the face of site difficulties due to mining subsidence and a variety of other extra costs not normally encountered. The extent of the economies which have been made is shown by a net cost of £233 10*s*. 0*d*. per place (based on 360 cost places) and 59*s*. 5*d*. per sq. ft. with usable floor space provided on the generous scale of 78·6 sq. ft. per place. The current Ministry of Education targets of £250 per place and 64*s*. per sq. ft. show that the actual cost is nearly 5*s*. per sq. ft. (about 8 per cent) below the target cost.

Some time has been spent on a thorough cost analysis of the design and this has revealed some of the origins of the low cost as well as providing an opportunity for a certain amount of experiment in methods of cost analysis. The description which follows therefore includes an account of the analysis and presents some of the results which have been obtained. Lack of comparable figures for other buildings prevents any firm conclusions from being drawn at present, but it is thought worth while to publish the results as they stand in the hope that they may be useful to other architects and perhaps encourage a wider exchange of information in this field than is customary at present.

Programme. The school is the first instalment of a four-form entry school and

The general site plan

provision is made in the design for extension to this size at a later date. This has meant that the building and equipment are in some respects in excess of immediate needs. The boiler house and heating ducts for instance are designed to provide the full heating load of the complete four-form entry school and the administration and staff rooms are similarly oversized. Although the school is designed for a basic population of 300 boys in ten classes of 30 each, it has been necessary to provide for up to 60 per cent overcrowding in the immediate future when the effects of the post-war increase in the birth rate become evident in the 11–15 year age range of the population. This will mean that for some years the school may have to accommodate as many as 500 boys in classes of 40 or more, and the scale of provision of cloakroom and lavatory facilities has been increased accordingly. Abnormal expenditure has also been necessary in the kitchen, which is to supply meals to the surrounding primary schools as well as the new secondary school and has thus been designed for 615 meals daily—a 150 per cent increase on the provision usually made in schools of this size.

Apart from these basic design requirements, set out in Table I, the schedule of accommodation in the same table shows that the more detailed space requirements are conventional and demand slightly more than the minimum teaching area in phase I, and slightly less in phase II. For reasons connected with subsidence risk, which will be discussed later, the building is divided into a number of separate blocks connected by structurally detached links and covered ways, as indicated by the plan opposite. The general teaching rooms are grouped in two-storey blocks (P, L and O). Block O contains a science demonstration room and is related to a room for plants and animals and the science laboratories (blocks N and M). One of the science laboratories is used in phase I as an art room. The handicrafts rooms (block K) are isolated from the rest in order to increase sound insulation. The grouping of the remaining elements of the plan (the service and assembly spaces) is influenced by the fact that in phase I the assembly hall is also used as a gymnasium and the small hall is used for dining. Other two-storey blocks contain the library, which is placed at the centre of the school over the entrance hall, and the administration and staff rooms. The floor space distribution for phase I is shown in the area analysis, Table II.

Table I—Basic Design Requirements and Schedule of Accommodation

Basic Design Requirements	PHASE I—TWO-FORM ENTRY	PHASE II—FOUR-FORM ENTRY
Number of pupils	Initially up to 500, decreasing to 300 later	600
Minimum teaching area ..	14,180 sq. ft.	26,680 sq. ft.
Number of cost places ..	360	680
Kitchen capacity	615 meals per day*	? 500 meals per day*
Number of form units ..	10+	20
Provision of cloakroom and lavatory accommodation based on	400 pupils	600 pupils

Schedule of Accommodation		PHASE I					PHASE II				
Group	Teaching space	Number of spaces	Area of each space (sq. ft.)	Total teaching area (sq. ft.)	Number of teaching spaces	Number of form bases	Number of spaces	Area of each space (sq. ft.)	Total teaching area (sq. ft.)	Number of teaching spaces	Number of form bases
A	Hall	1	2,800		1	—	1	2,800		1	—
	Small hall ..	1	1,500		1	—	1	1,500		1	—
	Gymnasium ..	—	—		—	—	1	2,800		1	—
				4,300					7,100		
B	Library ..	1	960		—	—	1	960		—	—
				960					960		
C	General teaching rooms ..	8	520		8	8	10	520		10	10
		2	600		2	2	4	600		4	4
							2	1,000		2	2
				5,360					9,600		
D	Practical accommodation										
	Science ..	1	960		1	—	2	960		2	—
	Woodwork ..	1	850		½	—	2	850		1	—
	Metalwork ..	1	850		½	—	2	850		1	—
	Art	1	960		1	—	1	960		1	1
	Craft	—	—		—	—	1	960		1	1
	General practical ..	—	—		—	—	2	900		2	2
				3,620					9,040		
	TOTALS.. ..	17		14,240	15	10	30		26,700	27	20

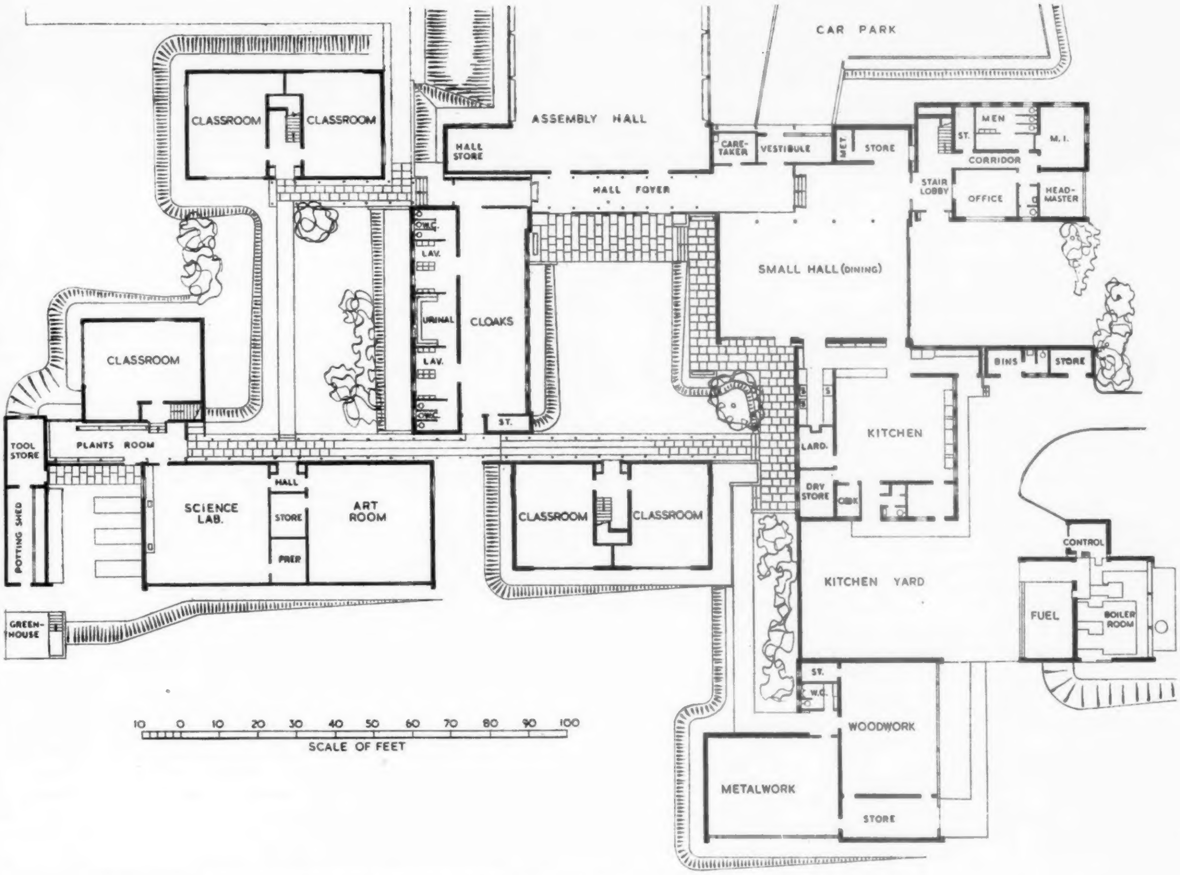
* Kitchen supplies meals to other schools

Site Conditions and Subsidence Protection. The site is reasonably flat, with a maximum gradient of 1 in 25 from east to west, and excavation has been kept to an average depth of 2 ft. below the existing ground level. The subsoil is gravel below 6 in. to 9 in. of vegetable soil, followed by rock at about 5 ft. below the surface. Several worked and unworked coal seams lie at various depths underneath the site, and although settlement in the worked seams is assumed to be complete the present mining programme is that coal will be extracted from the other seams in about ten years' time. This, with the fact that the rock is disturbed by a geological fault about 100 ft. away from the site, means that severe ground subsidence is to be expected within the life of the building. The diagram on page 435 shows in an exaggerated way the effect that mining subsidence of a certain type can have on a building. As the coal is taken out the working face moves forward, and the ground above is deprived of support when the galleries behind the face are progressively abandoned and settlement allowed to take place. This will happen after a certain length of time, determined by the nature of the overburden and the method of getting the coal. The effect on the surface is a depression of the ground which moves in advance of the working face and is often called the subsidence wave. The diagram shows that the forces to which a building is subjected as the wave passes beneath it change radically as the crest and trough of the wave move by in succession—positions 1 to 5 in the diagram.

1. The building in its original position before settlement begins.

2. The building on the crest of the subsidence wave. Tensile ground forces tend to tear the structure apart and cantilever moments break its back.

3. The building on the flank of the wave. The structure is subjected to eccentric loads due to its departure from the vertical.



The ground floor plan. There is a first floor over each of the classroom blocks and the headmaster's block

4. The building in the trough of the wave. Compressive ground forces exert a crushing effect and the structure must bridge across the centre of the ground slab where support is lacking. Forces are the reverse of those in 2.

5. The building is stable once more at a level below its original position.

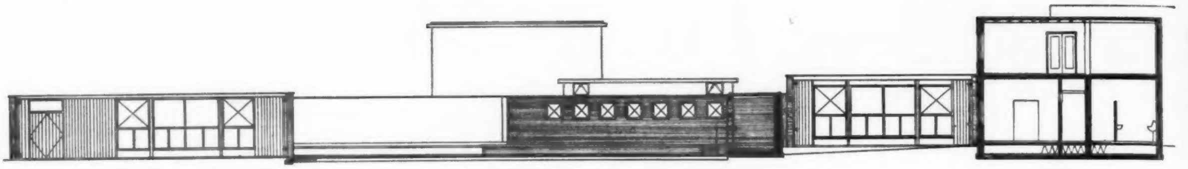
Of all the forces to which it is subjected, 2 is probably the most dangerous to the building.

In fact the sequence is rarely as simple as this. Much depends on the structure of the ground, and the presence of faults and disturbances in the rock strata may give rise to discontinuities in the subsidence wave and sudden fractures at the surface. There are certain circumstances, however, which may alleviate the grim prospect of total destruction. First, the forces acting in positions 2 and 4 tend to cancel each other, and secondly, although the level of the building may drop several feet during the settlement period, the length of the subsidence wave is usually so much greater than the longest dimension of the building that the day-to-day settlement may be not more than a few inches. Experience has so far suggested that if ground slab lengths are kept below 60 ft. differential settlement will be held down to reasonable limits.

It is thus clear that the most elementary precaution to be taken against subsidence must be to keep the ground area of the building as small as possible and to divide the structure into independent bays whose plan dimensions do not exceed 60 ft. Complete protection against differential settlement within these limits can only be provided by a foundation slab which first can withstand the tensile and compressive forces in the ground, and secondly has sufficient flexural strength to resist the hogging and sagging moments due to the weight of the building when it is deprived of support at the edge or centre.

The first of these requirements can be met quite simply by putting the necessary amount of steel into the slab and reducing the lateral forces transmitted from the ground to the slab by making the friction between them as small as possible. The second requirement, resistance against bending, can only be satisfied at some expense, and is best justified, for instance, in the case of a multi-storey building in which high foundation costs may be distributed over a total floor area which is large in relation to the area of the ground slab.

In the case of the school at Darton there was not enough money available to provide complete subsidence protection—specially in view of the abnormal items of expenditure which have already been described. It was therefore decided to accept the increased cost of maintenance which might arise when settlement occurred in the future and provide partial protection against horizontal forces only. To this end the ground slabs are laid on a bed of red shale to reduce friction and are dimensioned and reinforced to resist compressive and tensile forces calculated on the basis of a coefficient of friction between ground and slab of 2/3. All the two-storey blocks and as many of the others as possible have been restricted to plan dimensions below 60 ft. and provided with independent structures and ground slabs. Where two independent structures have to be connected, 9 in. wide movement joints are provided in the walls and sealed with 24 s.w.g. corrugated copper sheet. The roof is carried over these joints by means of loosely mounted woodwool or compressed straw slabs. The ground slab is discontinuous at the joint and the 3 in. gap between the edges of adjacent slabs is bridged by a woodwool slab. Floor and roof



Section through headmaster's block, showing elevation of small hall, kitchen and woodwork room

screeds and finishes are carried over the joints without interruption and will probably need repair if settlement takes place.

Method of Cost Analysis—Classification. Before going on to describe the distribution of cost and the different constructional methods it is necessary to define the forms of classification which have been used for the analysis.

The first need is for a component classification which analyses the construction and materials of the building in such a way that the study of comparative costs is made easy and the needs of day-to-day cost planning are satisfied whatever the form of the building and its construction. The only component classification in general use at present in the building industry is that used in bills of quantities. This is based mainly on the traditional division of trades in the industry and pays scant attention to the precise function and location of each component in the building. The Ministry of Education *Building Bulletin on Cost Study* (No. 4, March 1951) suggests an improved classification whose chief shortcoming is that the different items are grouped in such a way that the basic categories of structure, cladding, services, etc., cannot readily be abstracted, and possibilities of rapid comparison are therefore limited. The classification described below is basically a rearrangement of the Ministry of Education proposals and attempts to resolve some of these difficulties. It is only tentative, however, and will probably have to be superseded several times before a satisfactory form is achieved.

The six main categories of building components are defined as STRUCTURE, CLADDING, PARTITIONS, FINISHES, EQUIPMENT and SERVICES. For the purposes of cost analysis CONTRACT charges are added as the seventh. Each of these is divided into related families of building components (or items of cost) as follows:

STRUCTURE (S). Components whose main function is to collect and transmit the building loads to the ground.

S.1. *Foundations*. Work below ground floor level excluding the screeds and finishes of the ground floor slab. (Includes provision for service runs within the perimeter of the building.)

S.2. *Frame*. The primary load-bearing structure excluding walls. (Includes columns, primary and perimeter beams in floors and roofs, trusses, rigid frames and bracing. Excludes secondary frame elements such as secondary floor and roof beams, purlins and cladding rails which are classified under S.4—suspended floors, S.5—roof structure and C.2—cladding frames—as the case may be.)

S.3. *Lintels*. Beams over openings in load-bearing walls. (An anomalous category arising from the difficulty of knowing whether to classify load-bearing walls as structure, cladding or partition components—see C.3 and P.2 below. It might be better to distribute the cost over floor, roof and cladding structures according to the principal load being carried.)

S.4. *Suspended Floors*. Floor slabs and stairs excluding finishes. (Includes secondary floor beams, handrails and balusters.)

S.5. *Roof Structure*. Roof slabs, eaves and fascias excluding waterproofing. (Includes secondary roof beams and purlins. Excludes flashings, gutters and rainwater pipes unless formed in the structure of the roof slab.)

CLADDING (C). Components whose main function is to protect the inside of the building from the weather and preserve the necessary internal climate.

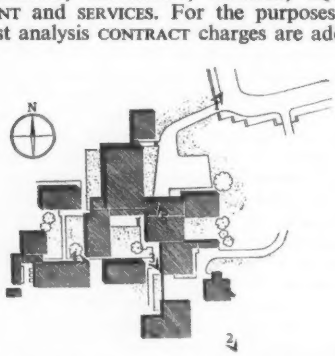
C.1. *Damp-proof Membranes*. (Includes vertical and horizontal damp-proof courses in masonry and the waterproofing of retaining walls and ground slabs. Excludes measures other than damp-proof courses for waterproofing vertical cladding surfaces and roofs.)

C.2. *External Cladding Frames*. The cladding structure. (Includes all cladding rails and posts which are not part of the primary structure, window and door frames, external doors, sub-frames, fixing and coupling members for panels and any frame used to support the external cladding.)

C.3. *External Cladding Panels*. The cladding surfaces. (Includes external load-bearing walls whose primary function is assumed to be enclosure with their structural contri-

Table II—Area Analysis (Phase I)

Group	Accommodation	Area (sq. ft.)	Percentage of total	Area per place (sq. ft.) (based on 360 cost places)
A	Hall, stage, small hall, storage ..	6,079·2	21·5	16·9
B	Library, storage	980·8	3·5	2·6
C	General and practical classrooms, storage	10,101·8	35·7	28·1
D	Kitchen	1,725·8	6·1	4·7
E	Storage of pupils' belongings, changing rooms, sanitary accommodation for pupils	2,609·0	9·2	7·2
F	Staff, services and administration rooms (including boiler house but excluding kitchen)	2,985·8	10·6	8·3
G	Entrance hall and circulation ..	2,981·2	10·5	8·2
	Covered ways	840·0	2·9	2·6
	TOTALS	28,303·6	100·0	78·6



Shadowed block plan of the buildings. The numbered angles refer to the viewpoints from which the accompanying perspectives were set up

bution, as far as cost analysis is concerned, made free of charge. Includes also all non-structural external panels and infilling, waterproofing and flashings applied to vertical surfaces, facing brickwork and rendering. Excludes glazing, internal wall finishes, insulation and the internal surfaces of composite panels.)

C.4. *External Glazing.*

C.5. *Roof Cladding.* Waterproofing components for the roof structure. (Includes screeds, waterproof membranes and flashings. Excludes gutters.)

C.6. *Roof Lights.* (Excludes work involved in forming the opening and upstand in the roof which is classified under S.5.)

PARTITIONS (P). Screening components whose main function is to define the interior spaces of the building.

P.1. *Internal Partition Frames.* The screening structure. (Includes internal window frames, doors and door frames, fixing and coupling members for panels and any frame used to support an internal screen.)

P.2. *Internal Partition Panels.* The screening surfaces. (Includes internal load-bearing walls on the same basis as in C.3. Also cement block and brick partitions, internal glazing, curtains, panels and sheet materials used as partitions. Excludes wall finishes and the inner leaves and surfaces of composite cladding panels.)

P.3. *W.C. Cubicles.* (An anomalous category whose isolation is only justified in buildings such as schools where such an item is liable to make an appreciable contribution to the total cost. It would normally be distributed between P.1 and P.2.)

FINISHES (F). Internal and external surface treatments and components where these are not an intrinsic part of the structure, cladding and partition components.

F.1. *Floor Finishes.* Surfaces additional to the structural floor slab. (Includes screeds, skirtings and the surface treatment of the treads and risers of stairs.)

F.2. *Wall Finishes.* Internal surfaces additional to the cladding and partition panels. (Includes the extra cost of internal facing brickwork, preparation for plaster and plastering, sheet materials and their fixing members where these are additional to the partition or cladding frame and panel, insulation and the inner leaves of composite cladding panels, and linings to the reveals of openings where these are not part of a door or window frame. Excludes the additional cost of external facing brickwork, which is classified under C.3.)

F.3. *Ceiling Finishes.* Internal and external surfaces additional to the structural floor and roof. (Includes a similar group to F.2, suspended ceilings, and linings to the soffits of openings and beams.)

F.4. *External Painting.* External surface protection and treatment not included in C.2 and C.3.

View of foyer, drawn from viewpoint 3

F.5. *Internal Painting.* Internal surface protection and treatment not included in F.2 and F.3.

EQUIPMENT (E). Fixed furnishing components including installation work.

E.1. *Cloakroom Fittings.* Components for clothes storage.

E.2. *Built-in Furnishings.* (Includes shelves, cupboards, storage units other than for clothes, fixed seating, fire-fighting equipment.)

E.4. *Ironmongery.*

E.5. *Sanitary Fittings.* (Includes installation work and ancillary components such as draining boards. Excludes connection to the relevant services.)

E.6. *Cooking Equipment.*

E.7. *Paved Areas and Playgrounds.* Ground treatment adjacent to the building.

E.8. *Covered Ways.* Shelter for external circulation space.

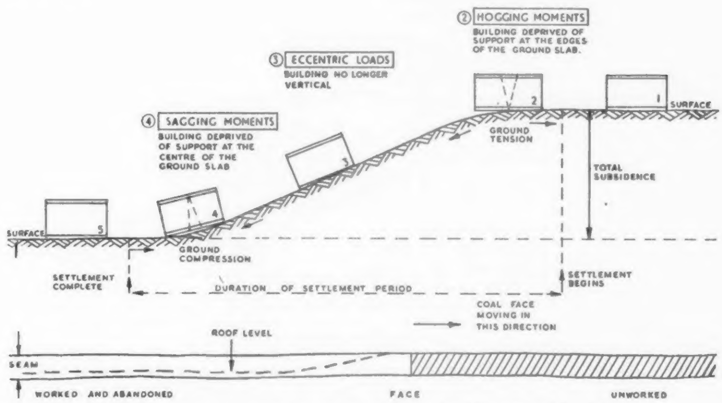
SERVICES (SE). Components whose main function is the distribution of water, heat, light and power and the disposal of waste.

SE.1. *External Plumbing.* (Includes rain-water collection and disposal and waste disposal *above* ground floor level and *outside* the perimeter of the building.)

SE.2. *Internal Plumbing.* (Includes hot and cold water supply, storage tanks, thermal insulation to pipes and tanks, connections to sanitary fittings and waste disposal *above* ground floor level and *inside* the perimeter of the building.)

SE.3. *External Drainage.* (Includes waste disposal *below* ground floor level and *outside* the perimeter of the building up to and including the adjacent manholes.)

SE.4. *Heating Installation.* (Includes the complete space-heating installation, provision for the supply—but not the distribution—of hot water, means of mechanical ventilation, chimneys and flues. Excludes ducts below ground floor level, which are classified under S.1.)



Subsidence diagram showing the forces to which a building is subjected

SE.5. *Electrical Installation.*

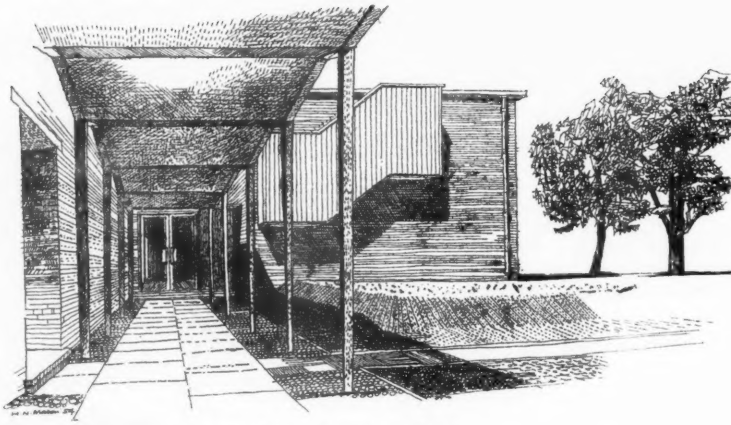
SE.6. *Gas Installation.*

CONTRACT (CON). Costs related to the administration and organisation of the building work.

CON.1. *Preliminary Costs and Insurance.*

CON.2. *Contingencies.*

Experience has shown that the component classification used for the Darton cost analysis can be improved in various ways. The stair structure, for instance, would be better analysed as a separate category and not included with the suspended floor components. And greater precision and flexibility would be achieved by the division of C.2 and P.1 (cladding frames and partition frames) into doors and windows on the one hand and panel frames on the



View of plant room entrance, drawn from viewpoint 4

Table III

Group 1: Class Space. Blocks P, L. No. of Storeys: 2. Floor Area: 5,037 sq. ft. Accommodation: 8 classrooms in two 2-storey blocks

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	2/8·6		9/10·1 (18·0%)	23/1·8 (42·3%)	See text
	S2 Frame	—				—
	S3 Lintels	0/5·5				See text
	S4 Suspended floors	3/9·1				6½-in. prestressed precast R.C.
	S5 Roof structure	2/10·9				6½-in. prestressed precast R.C.
CLADDING	C1 D.P. membranes	0/5·0		11/3·8 (20·7%)		See text
	C2 External frames	3/0·3	8/9·1			See text
	C3 External panels	5/4·0				9-in. solid brick + water repellant ¼-in. plywood
	C4 External glazing	0/4·8				See text
	C5 Roof cladding	1/11·4				See text
	C6 Roof lights	0/2·3				See text
PARTITIONS	P1 Internal frames	0/3·5		1/11·9 (3·6%)		See text
	P2 Internal panels	1/8·4				4½-in. and 9-in. brick
	P3 W.C. cubicles	—				See text
FINISHES	F1 Floor finishes	2/9·2		7/0·7 (13·0%)		⅛-in. thermoplastic tile
	F2 Wall finishes	2/1·7				Fairfaced brick, ½-in. fibreboard, 3/16-in. hardboard, ¼-in. asb. cement
	F3 Ceiling finishes	1/2·5				½-in. fibreboard, ¼-in. asb. cement
	F4 External painting	0/1·5				See text
	F5 Internal painting	0/9·8				See text
EQUIPMENT	E1 Cloakroom fittings ..	—		6/1·6 (11·2%)		—
	E2 Built-in furniture	0/2·0				See text
	E3 Teaching equipment ..	3/3·7				See text
	E4 Ironmongery	0/3·7				See text
	E5 Sanitary fittings	—				—
	E6 Cooking equipment ..	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES	SE1 External plumbing ..	0/1·6		13/9·1 (25·1%)		See text
	SE2 Internal plumbing ..	—				—
	SE3 External drainage ..	2/0·5				See text
	SE4 Heating installation ..	8/5·8				See text
	SE5 Electric installation ..	3/1·2				See text
	SE6 Gas installation	—				See text
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (8·4%)		
	CON2 Contingencies	1/4·9				
TOTAL ..		54/8·3		(100·0%)		

other. Possibilities of quick comparison between one structural method and another would similarly be enlarged by a subdivision of C.3 and P.2 (cladding panels and partition panels) into load-bearing, non-structural and glazed panels. The equipment category is the one most influenced by the function of the building and the form of breakdown within it is therefore likely to change for different building types. The one described above refers particularly to schools and may be unsuitable for other buildings.

Apart from isolating the costs of different components, the method of analysis should also distinguish between those parts of the building whose space needs and specifications are significantly different. In a building whose accommodation is as varied as that of a secondary school, average costs for the whole building may mask wide variations in the cost of the same component used in different parts of the school. If the cost analysis is to reflect the component costs with accuracy a further classification is therefore needed which will group together those parts of the building which first of all can be easily isolated structurally, and secondly have broadly the same kind of construction, the same structural dimensions, the same area of separately enclosed volumes and number of storeys, and a similar standard of equipment and finish. For secondary schools the most detailed function classification likely to be necessary to satisfy these requirements is:

(i) CLASS SPACE Small scale. Max. structural span = 25 ft. Mainly multi-storey.	(*a*) General class space. (*b*) Special class space—e.g. Art, Science, Library. (*c*) Administration.
(ii) SERVICE SPACE Medium scale. Max. structural span = 35 ft. Mainly single-storey.	(*a*) Service space—e.g. kitchen, changing room, lavatories and cloakrooms, boiler house. (*b*) Workshop space—e.g. woodwork, metalwork.

Table IV

Group 2: Class/Assembly Space. Blocks E, F. No. of Storeys: 1 and 2. Floor Area: 5,939·1 sq. ft. Accommodation—Small Hall and Main Entrance, Library on first floor, Administration on 2 storeys

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	4/1·6		12/0·2 (21·9%)	25/9·6 (47·1%)	See text
	S2 Frame	3/0·5				R.S. sections, 6·1 lb./ft.²
	S3 Lintels	0/3·6				See text
	S4 Suspended floors	2/7·6				6-in. hollow tile and precast R.C.
	S5 Roof structure	1/10·9				2-in. woodwool and compressed straw on timber joists
CLADDING	C1 D.P. membranes	0/6·2		10/2·6 (18·7%)		See text
	C2 External frames	2/10·7	6/10·0			See text
	C3 External panels	4/1·0				9-in., 11-in., 13½-in. cavity brick and 9-in. solid brick, weatherboarding
	C4 External glazing	0/7·3				See text
	C5 Roof cladding	1/11·8				See text
	C6 Roof lights	0/1·6				See text
PARTITIONS	P1 Internal frames	0/11·6		3/6·8 (6·5%)		See text
	P2 Internal panels	2/4·9				4½-in. and 9-in. brick, 2-in., 3-in. and 4-in. concrete block
	P3 W.C. cubicles	0/2·3				See text
FINISHES	F1 Floor finishes	2/9·3		6/6·4 (11·9%)		⅛-in. and $\frac{3}{16}$-in. thermoplastic tile, 2-in. gran.
	F2 Wall finishes	1/8·7				Fairfaced brick, fibreboard, asbestos cement sheet
	F3 Ceiling finishes	1/1·6				Fireboard and asbestos cement
	F4 External painting	0/1·2				See text
	F5 Internal painting	0/9·6				See text
EQUIPMENT	E1 Cloakroom fittings	—		3/8·2 (6·6%)		—
	E2 Built-in furniture	0/5·3				See text
	E3 Teaching equipment	—				—
	E4 Ironmongery	0/3·7				See text
	E5 Sanitary fittings	0/7·0				See text
	E6 Cooking equipment	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES	SE1 External plumbing	0/2·3		14/3·9 (26·1%)		See text
	SE2 Internal plumbing	0/6·1				See text
	SE3 External drainage	2/0·5				See text
	SE4 Heating installation	8/5·8				See text
	SE5 Electric installation	3/1·2				See text
	SE6 Gas installation	—				—
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (8·3%)		
	CON2 Contingencies	1/4·9				
TOTAL		54/11·6		(100·0%)		

Table V

Group 3: Class Space. Blocks M, N, O. No. of Storeys: 1 and 2. Floor Area: 4,025·3 sq. ft. Accommodation: Science Room, Art Room, Plant Room, 2 Classrooms in one 2-storey block

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	4/1·7				See text
	S3 Frame	2/6·0				R.S. sections, 4·0 lb./ft.^{2}
	S3 Lintels	0/4·6		13/7·8 (24·8%)		See text
	S4 Suspended floors	2/2·9				6½-in. prestressed precast R.C., compressed straw on timber
	S5 Roof structure	4/4·6				6½-in. prestressed precast R.C.
CLADDING	C1 D.P. membranes	0/7·8				See text
	C2 External frames	3/6·2				See text
	C3 External panels	4/5·3	8/6·0	11/5·5 (21·0%)	26/5·5 (48·2%)	11-in. cavity brick + block, 9-in. solid brick, ½-in. weatherboard
	C4 External glazing	0/6·5				See text
	C5 Roof cladding	2/2·3				See text
	C6 Roof lights	0/1·4				See text
PARTITIONS	P1 Internal frames	0/4·8		1/3·7 (2·4%)		See text
	P2 Internal panels	0/10·9				9-in. brick, 3-in. block
	P3 W.C. cubicles	—				—
FINISHES ..	F1 Floor finishes	2/6·0				⅛-in. thermoplastic tile, 2-in. gran.
	F2 Wall finishes	1/4·6		5/6·8 (10·1%)		Fairfaced brick, fibreboard, hardboard, asbestos cement sheet
	F3 Ceiling finishes	0/8·0				Fibreboard, asbestos cement sheet
	F4 External painting	0/1·8				See text
	F5 Internal painting	0/10·4				See text
EQUIPMENT	E1 Cloakroom fittings ..	—				—
	E2 Built-in furniture	0/9·9				See text
	E3 Teaching equipment ..	0/2·4				See text
	E4 Ironmongery	0/3·7		3/11·5 (7·2%)		See text
	E5 Sanitary fittings	0/3·3				See text
	E6 Cooking equipment ..	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES ..	SE1 External plumbing ..	0/2·2				See text
	SE2 Internal plumbing ..	0/4·5				See text
	SE3 External drainage ..	2/0·5		14/5·9 (26·2%)		See text
	SE4 Heating installation ..	8/5·8				See text
	SE5 Electric installation ..	3/1·2				See text
	SE6 Gas installation	0/3·7				See text
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (8·3%)		
	CON2 Contingencies	1/4·9				
TOTAL ..		55/0·3		(100·0%)		

(iii) ASSEMBLY SPACE — Main hall, small hall, dining-space, entrance space, gymnasium
Large scale.
Max. structural span = 50 ft.
Mainly single-storey.

In the Darton analysis this ideal classification has had to be modified owing to the form of the bills of quantities from which the analysis was made, but although contradictions are evident it has been possible to maintain the broad divisions of function to a sufficient extent to reveal significant differences in cost between one part of the building and another.

Method of Cost Analysis—Choice of Units. The costs and quantities on which the analysis is based are those contained in the priced bills of quantities submitted by the successful tenderer. The second lowest tender was within 1 per cent of the lowest, and the third lowest was only 0·6 per cent higher. Furthermore the three contractors responsible had their headquarters from 7 miles to 200 miles away from the site, so that the effects of local conditions and other variables may be to some extent ruled out.

The cost analysed is the net cost as defined in the Ministry of Education *Building Bulletin No.* 4—the total cost of the building including in this case all abnormal charges due to subsidence risks and phased construction, but excluding the following items: (i) Drainage beyond manholes adjacent to the building. (ii) Roads, paths, fencing and all external works not classifiable under category E.7. (iii) Site layout and planting. (iv) Caretaker's and head teacher's houses. (v) Playing field preparation.

The unit chosen for the analysis is the net cost per sq. ft. of usable floor area (in shillings and pence to the nearest tenth of a penny). This unit is recommended in *Bulletin No.* 4 as being easier to break down than the cost per place and more truly indicative of the functional value of money spent that the cost per cu. ft. This has been borne out by the present study.

The results of the analysis are tabulated in Tables III to XI using the forms of classification discussed above. Tables III to X present the cost breakdown of the eight groups of accommodation which make up the school in order of ascending total cost per sq. ft. of floor area. Table XI

Table VI

Group 4: Service Space (Workshops). Block K. No. of Storeys: 1. Floor Area: 2,024·9 sq. ft. Accommodation: Metalwork, Woodwork, Lavatory, 2 Stores

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	6/1·7				See text
	S2 Frame	2/8·5				R.S. sections, 2·7 lb./ft.^{2}
	S3 Lintels	0/2·7		13/4·1 (23·1%)		See text
	S4 Suspended floors	—				—
	S5 Roof structure	4/3·2				3-in. woodwool on M.S. tees at 2 ft. 0 in. c./c.
CLADDING	C1 D.P. membranes	0/9·8				See text
	C2 External frames	3/3·9				See text
	C3 External panels	3/6·3	8/1·4	12/3·2 (21·2%)	29/0·6 (50·2%)	11-in. cavity brick, ½-in. hardwood weatherboard
	C4 External glazing	1/3·2				See text
	C5 Roof cladding	3/4·0				See text
	C6 Roof lights	—				—
PARTITIONS	P1 Internal frames	0/7·1		3/5·3 (5·9%)		See text
	P2 Internal panels	2/7·3				9-in. brick
	P3 W.C. cubicles	0/2·9				Metal-faced plywood
FINISHES	F1 Floor finishes	3/1·3				Woodblock, 2-in. gran., 2-in. concrete tile, ⅞-in. quarries
	F2 Wall finishes	0/9·1		4/10·8 (8·5%)		Fairfaced brick, fibreboard + insulation, plaster
	F3 Ceiling finishes	0/1·4				Exposed woodwool
	F4 External painting	0/1·6				See text
	F5 Internal painting	0/9·4				See text
EQUIPMENT	E1 Cloakroom fittings	—				—
	E2 Built-in furniture	0/7·9				See text
	E3 Teaching equipment	—				See text
	E4 Ironmongery	0/3·7		4/5·2 (7·7%)		See text
	E5 Sanitary fittings	1/1·4				See text
	E6 Cooking equipment	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES	SE1 External plumbing	0/1·4				See text
	SE2 Internal plumbing	0/9·5				See text
	SE3 External drainage	2/0·5		14/10·6 (25·7%)		See text
	SE4 Heating installation	8/5·8				See text
	SE5 Electric installation	3/1·2				See text
	SE6 Gas installation	0/4·2				See text
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (7·9%)		
	CON2 Contingencies	1/4·9				
TOTAL		57/10·3		(100·0%)		

summarises these costs as average values for the whole school. Sub-totals are given for: (*a*) Each main category of structure, cladding, etc. (*b*) The vertical wall cladding—items C.2, C.3 and C.4. (*c*) The building carcase—structure, cladding and partitions omitting finishes, equipment and services. A percentage value shows the proportion of the total cost of the group represented by each sub-total. A brief indication of the methods of construction used in each group is noted for all those components which are not standard throughout the school. Apart from these variations the following items are common to each group:

S.1. *Foundations.* 9 in.–12 in. R.C. rafts (average 7 lb. per sq. yd. reinforcement) laid on building paper on a 6 in. bed of red shale.

S.3. *Lintels.* Combination of precast and *in situ* R.C. and ⅛ in. thick mild steel pressings.

C.1. *D.P. Membranes.* Two coats liquid water repellent on ground slabs; bituminous felt D.P.C.'s

C.2. *External Frames.* Hot-dipped galvanised purpose-made steel window frames fixed to masonry or hardwood sub-frames; hardwood, glazed, flush-faced or weatherboarded doors in hardwood frames; softwood studding (mainly 3 in. by 2 in.) for weatherboarding and plywood cladding panels.

C.4. *External Glazing.* Combinations of 26 and 32 oz. clear sheet, ¼ in. plain and wired polished plate, ¼ in. wired cast, ¼ in. armour-plate.

C.5. *Roof Cladding.* 1½ in. screed or woodwool or concrete, 1½ in. foamed slag concrete plus ¾ in. screed on prestressed concrete; three layers mineral finished felt and 14 s.w.g. zinc flashings.

C.6. *Roof Lights.* 4 ft. by 4 ft. and 4 ft. by 8 ft. aperture; curved corrugated plastic sheet on pressed steel upstands with pressed steel louvres below.

P.1. *Internal Frames.* 1¾ in. hardwood faced flush doors in profile B or C pressed steel frames.

Table VII

Group 5: Service Space. Block Q. No. of Storeys: 1. Floor Area: 1,800·4 sq. ft. Accommodation: Lavatory, Cloakroom

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	4/8·5				See text
	S2 Frame	0/7·9				Small frame for clerestory
	S3 Lintels	0/3·7		11/6·6		See text
	S4 Suspended floors	0/4·0		(18·3%)		Metal steps in short flights
	S5 Roof structure	5/6·5				Clerestory—compressed straw; remainder—6-in. hollow tile
CLADDING	C1 D.P. membranes	0/9·6				See text
	C2 External frames	2/8·8				See text
	C3 External panels	4/7·8	7/8·3	12/3·5	27/6·2	11-in. cavity brick + blocks
	C4 External glazing	0/3·7		(19·5%)	(43·6%)	See text
	C5 Roof cladding	3/3·1				See text
	C6 Roof lights	0/6·5				See text
PARTITIONS	P1 Internal frames	0/2·1		3/8·1		See text
	P2 Internal panels	2/2·3		(5·8%)		9-in. brick, 2-in. block
	P3 W.C. cubicles	1/3·7				See text
FINISHES	F1 Floor finishes	2/6·9				2-in. gran., ⅞-in. quarries
	F2 Wall finishes	1/3·1				Fairfaced brick, fibreboard, plaster
	F3 Ceiling finishes	0/8·5		5/3·7		Fibreboard, plaster
	F4 External painting	0/1·1		(8·4%)		See text
	F5 Internal painting	0/8·1				See text
EQUIPMENT	E1 Cloakroom fittings	2/2·3				Hooks in 2 rows, staggered at 6 in. c./c. on hardwood frames
	E2 Built-in furniture	0/0·9				See text
	E3 Teaching equipment	—		10/1·9		—
	E4 Ironmongery	0/3·7		(16·1%)		See text
	E5 Sanitary fittings	5/2·8				See text
	E6 Cooking equipment	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES	SE1 External plumbing	0/1·7				See text
	SE2 Internal plumbing	1/9·8				See text
	SE3 External drainage	2/0·5		15/7·0		See text
	SE4 Heating installation	8/5·8		(24·6%)		See text
	SE5 Electric installation	3/1·2				See text
	SE6 Gas installation	—				—
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1		
	CON2 Contingencies	1/4·9		(7·3%)		
TOTAL		63/1·9		(100·0%)		

P.3. *W.C. Cubicles*. Metal-faced plywood.

F.4. *External Painting*. Two undercoats and one finishing coat on wood and metal; two coats preservative and two coats synthetic varnish on hardwood.

F.5. *Internal Painting*. As for F.4 plus two coats emulsion paint on plaster, sheet materials, woodwool, brickwork and concrete.

E.2. *Built-in Furniture*. Hardboard shelves generally; grano shelves and softwood storage cupboards in kitchen.

E.3. *Teaching Equipment*. Veneer-faced blockboard chalk boards.

E.4. *Ironmongery*. B.M.A. finish except for anodised aluminium door pulls.

E.5. *Sanitary Fittings*. White glazed fireclay, 35 basins, 7 sinks, 16 W.C.'s, 35 urinals, 2 drinking fountains.

E.6. *Cooking Equipment* (kitchen only). 7 white glazed sinks, 3 galvanised sinks, 4 tables, 1 pastry bench, 1 electric mixer, 1 electric slicer, 1 electric potato peeler, 1 electric food preparation machine, 3 30-gal. gas boiling pans, 1 single unit and 1 double unit gas steaming oven, 1 two-tier gas general purpose oven, 1 double unit gas range.

E.7. *Playgrounds, etc.* Surface materials—cobble paving, 2 in. precast concrete slabs, 2½ in. and 3 in. tarmacadam.

E.8. *Covered Ways*. Fabricated from aluminium alloy sheet and extrusions on a 6 ft. by 5 ft. structural bay.

SE.1. *External Plumbing*. 3 in., 4 in. and 5 in. diameter C.I. pipes; R.W. gutters formed in structure of roof slabs.

SE.2. *Internal Plumbing*. 4 in. diameter C.I. drains, connectors, traps, etc.; ½ in.–3 in. diameter copper supply and waste pipes; preformed copper waste fittings.

SE.3. *External Drainage*. 5 ft. average depth of trenches and manholes; 4 in. and 6 in. diameter C.I. and stoneware drains laid on concrete for soil drainage; 4 in. diameter pitch-impregnated fibre pipes laid in 12 in. bed of topsoil for surface water.

SE.4. *Heating Installation*. L.P.H.W. wall radiators for 80 per cent of total floor area; warm-air heating for 20 per cent.

SE.5. *Electric Installation*. Screwed steel conduit.

Table VIII

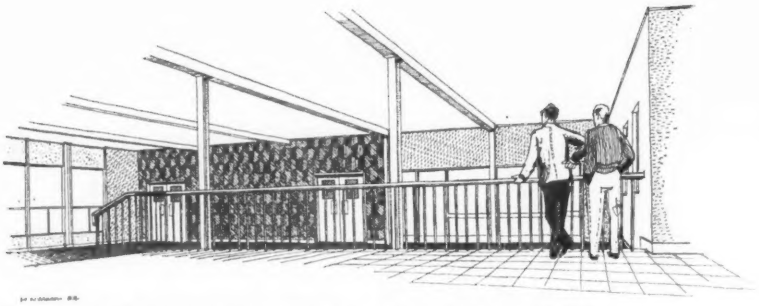
Group 6: Assembly Space. Blocks A, B, C, D. No. of Storeys: 1. Floor Area: 5,632·2 sq. ft. Accommodation: Assembly Hall, Foyer, Changing Room, Link

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	6/4·4		17/0·5 (26·1%)	33/2·1 (50·8%)	See text
	S2 Frame	4/7·1				R.S. sections, 4·1 lb./ft.²
	S3 Lintels	0/4·3				See text
	S4 Suspended floors	1/10·7				Stage—hardwood boards on joists
	S5 Roof structure	3/10·0				2-in. woodwool and compressed straw on steel or timber
CLADDING	C1 D.P. membranes	0/9·5		14/4·8 (22·1%)		See text
	C2 External frames	5/10·1	11/1·0			See text
	C3 External panels	4/4·1				11-in., 13½-in. cavity brick + block, weatherboarding, asb. cem. sheet
	C4 External glazing	0/10·8				See text
	C5 Roof cladding	2/6·3				See text
	C6 Roof lights	—				—
PARTITIONS	P1 Internal frames	0/4·4		1/8·8 (2·6%)		See text
	P2 Internal panels	1/3·4				9-in. brick, 2-in. block
	P3 W.C. cubicles	0/1·0				See text
FINISHES ..	F1 Floor finishes	4/9·4		9/6·5 (14·6%)		¾-in. concrete tile, ⅞-in. hardwood board on battens, thermopl. tile
	F2 Wall finishes	1/8·0				Plaster, fibreboard, glazed tiles
	F3 Ceiling finishes	2/0·8				Fibreboard, suspended ceiling fixed at 11 ft. 6 in. c./c.
	F4 External painting	0/2·1				See text
	F5 Internal painting	0/10·2				See text
EQUIPMENT	E1 Cloakroom fittings ..	0/4·0		3/4·8 (5·2%)		Hooks at 18 in. c./c. on hardwood and tube frames, seats, lockers
	E2 Built-in furniture	0/3·4				See text
	E3 Teaching equipment ..	0/0·1				See text
	E4 Ironmongery	0/3·7				See text
	E5 Sanitary fittings	0/1·4				See text
	E6 Cooking equipment ..	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES ..	SE1 External plumbing ..	0/2·7		14/7·4 (22·4%)		See text
	SE2 Internal plumbing ..	0/9·2				See text
	SE3 External drainage ..	2/0·5				See text
	SE4 Heating installation ..	8/5·8				See text
	SE5 Electric installation ..	3/1·2				See text
	SE6 Gas installation	—				—
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (7·0%)		
	CON2 Contingencies	1/4·9				
TOTAL ..		65/3·9		(100·0%)		

SE.6. *Gas Installation.* ½ in.–3 in. diameter copper pipes; cast brass fittings.

Comparative Costs of Components. *Services.* The whole school costs, Table XI, show that the biggest share of expenditure (25 per cent) of all the main categories is taken by services. In this category the biggest item is the heating installation, followed by the electrical installation and external drainage. The high cost of all these items is partly a reflection of the dispersed plan and therefore indirectly due to subsidence precautions. Another factor is the design of the heating installation for the complete four-form entry school and its consequently excessive size for the first instalment.

Structure. The next largest categories in the average costs shown in Table XI are structure and cladding, which each account for about 20 per cent of the total. In the structure category the foundation components are the most expensive, as might be expected. Among the individual groups of accommodation Table III shows the lowest foundation cost and this is due to two-storey construction. A foundation cost of 2*s.* 8·6*d.* per sq. ft. of floor area in a two-storey building is equivalent to a cost of 5*s.* 5·2*d.* per sq. ft. for the same components in single-storey construction. Comparison with the costs for single-storey blocks shows that their foundations are in some cases more expensive than this, so that the saving due to the distributions of foundation costs over two floors instead of one is not, in this case, offset by the increased structural loads. This effect may not be so marked in buildings where subsidence protection is not required and whose foundations are therefore cheaper than those at Darton. High costs are shown in the kitchen (Table IX) due to floor ducts and drainage accommodated in the depth of a gravel fill above the site slab, which is thus left uninterrupted and its efficiency in dealing with subsidence forces unimpaired. Abnormally high foundation costs are also found in the boiler house (Table X) due largely to excavation and retaining walls for the fuel bunker.



The dining hall, looking towards the servery. Drawn from viewpoint 5

The next highest cost to foundations in the structure category is that of the roof structure. Here again savings due to two-storey construction are evident in Table III —prestressed R.C.—and Table IV—mainly compressed straw slabs on timber. Of the single-storey groups, Table VIII has the cheapest roof structure—compressed straw slabs spanning 4 ft. on steel tees—followed by Table VI—3 in. woodwool on steel—and the kitchen and lavatory groups, Tables VII and IX, which have some hollow tile slabs with the additional complications of a clerestory. The saving due to the use of lightweight compressed straw slabs is increased when construction time, frame costs and roof cladding costs are taken into account. The cost of a screed must be added to that of the felt for the woodwool and R.C. slabs; they are heavier and take longer to build. On the other hand they will probably give higher thermal insulation and roof falls can be easily accommodated in the screed, whereas falls in a straw slab have to be dealt with by adjustments in the supporting structure.

Frames and suspended floors are the next in order of magnitude in the structure category, but the whole school costs for

Table IX

Group 7: Service Space. Blocks G, H. No. of Storeys: 1. Floor Area: 1,860·3 sq. ft. Accommodation: Kitchen, Stores

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	10/5·0		17/0·9 (18·9%)		See text
	S2 Frame	—				—
	S3 Lintels	0/8·9				See text
	S4 Suspended floors	0/1·2				Outside loading platform
	S5 Roof structure	5/9·8				Clerestory—5-in. hollow tile; remainder—2-in. woodwool
CLADDING	C1 D.P. membranes	0/11·9		14/1·5 (15·7%)	35/5·9 (39·3%)	See text
	C2 External frames	2/3·9	7/10·9			See text
	C3 External panels	5/5·2				11-in cavity brick + block
	C4 External glazing	0/1·8				See text
	C5 Roof cladding	4/8·5				See text
	C6 Roof lights	0/6·2				See text
PARTITIONS	P1 Internal frames	0/10·1		4/3·5 (4·7%)		See text
	P2 Internal panels	3/5·4				4½-in. and 9-in brick, 3-in. and 4-in. blocks
	P3 W.C. cubicles	—				—
FINISHES ..	F1 Floor finishes	5/5·6		10/4·1 (11·5%)		1¼-in. quarry tiles, 1½-in. gran.
	F2 Wall finishes	2/7·4				Fairfaced brick, plaster, glazed tiles
	F3 Ceiling finishes	1/0·1				¼-in. asbestos cement sheet, plaster
	F4 External painting	0/1·9				See text
	F5 Internal painting	1/1·1				See text
EQUIPMENT	E1 Cloakroom fittings ..	—		19/9·5 (22·0%)		—
	E2 Built-in furniture	2/8·0				See text
	E3 Teaching equipment ..	—				—
	E4 Ironmongery	0/3·7				See text
	E5 Sanitary fittings	1/1·0				See text
	E6 Cooking equipment ..	13/4·6				See text
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES ..	SE1 External plumbing ..	0/4·0		19/10·4 (22·1%)		See text
	SE2 Internal plumbing ..	3/5·2				See text
	SE3 External drainage ..	3/0·5				See text
	SE4 Heating installation ..	8/5·8				See text
	SE5 Electric installation ..	3/1·2				See text
	SE6 Gas installation	1/5·7				See text
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (5·1%)		
	CON2 Contingencies	1/4·9				
TOTAL ..		90/1·0		(100·0%)		

Table X

Group 8: Service Space. Block J. No. of Storeys: 1. Floor Area: 964·4 sq. ft. Accommodation: Boiler House, Fuel Bunker, Elevated Tank Room

Category	Component	Cost per sq. ft.				Specification
STRUCTURE	S1 Foundations	11/3·4		36/0·5 (40·0%)	61/5·0 (68·2%)	See text
	S2 Frame	13/0·7				R.S. sections
	S3 Lintels	0/9·6				See text
	S4 Suspended floors	4/8·2				Steel deck
	S5 Roof structure	6/2·6				4½-in. precase R.C., comp. straw
CLADDING	C1 D.P. membranes	0/1·8		25/4·5 (28·2%)		See text
	C2 External frames	6/1·0	20/11·3			See text
	C3 External panels	14/4·0				11-in., 13½-in. cavity brick; 13½-in. solid brick
	C4 External glazing	0/6·3				See text
	C5 Roof cladding	4/3·4				See text
	C6 Roof lights	—				—
PARTITIONS	P1 Internal frames	—		—		—
	P2 Internal panels	—				—
	P3 W.C. cubicles	—				—
FINISHES ..	F1 Floor finishes	1/6·3		4/10·4 (5·4%)		1-in.–2-in. gran., 1¼-in. quarry tiles
	F2 Wall finishes	1/3·3				Fairfaced brick, fibreboard
	F3 Ceiling finishes	0/7·4				Fibreboard and exposed concrete
	F4 External painting	0/6·1				See text
	F5 Internal painting	0/11·3				See text
EQUIPMENT	E1 Cloakroom fittings ..	—		2/7·9 (2·7%)		—
	E2 Built-in furniture	—				—
	E3 Teaching equipment ..	—				—
	E4 Ironmongery	0/3·7				See text
	E5 Sanitary fittings	—				—
	E6 Cooking equipment ..	—				—
	E7 Playgrounds, etc.	1/9·8				See text
	E8 Covered ways	0/6·4				See text
SERVICES ..	SE1 External plumbing ..	0/11·2		16/8·5 (18·6%)		See text
	SE2 Internal plumbing ..	2/1·8				See text
	SE3 External drainage ..	2/0·5				See text
	SE4 Heating installation ..	8/5·8				See text
	SE5 Electric installation ..	3/1·2				See text
	SE6 Gas installation	—				—
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (5·1%)		
	CON2 Contingencies	1/4·9				
TOTAL ..		90/2·9		(100·0%)		

these are not particularly significant, since the average includes framed, unframed, single- and two-storey structures in various combinations. Steel frame weights show a wide variation from 2·7 to 11·0 lb. per sq. ft. in the various groups of accommodation. The only accurate cost for suspended floors and stairs is given in Table III, which deals with the only purely two-storey block in the analysis. A cost of 3*s.* 9·1*d.* per sq. ft. of total floor area gives a cost of about 7*s.* 6*d.* per sq. ft. of the area of the suspended floor.

Cladding. In the cladding category the frame and panel costs are obviously the most important. Owing to the fact that load-bearing and non-structural cladding systems occur together in the same block it is not easy to isolate their costs and make a realistic comparison. Another complication is that, as a general rule, load-bearing walls are associated with heavy and expensive long-span roof and floor slabs, whereas non-structural cladding must depend on a predominantly framed structure which permits the use of lighter and cheaper floor and roof decks. Other things being equal, the non-structural cladding must allow for the extra cost of the structural frame but can absorb savings in floor and roof construction in order to achieve the same economy as the system employing load-bearing walls. In the latter case the cladding cost may absorb savings due to the absence of a frame but must allow for higher floor and roof costs.

The Darton analysis suggests that these variables tend to cancel each other, although the non-structural cladding, apart from windows, is largely of timber construction fabricated on the site, so the result may not be of general application. Using targets derived from the analysis, it is possible to balance the costs of the two systems, as in Table XII. With the average Darton value of 0·9 sq. ft. of floor to each sq. ft. of wall, the costs of 9*s.* and 8*s.* 6*d.* per sq. ft. of floor area shown in that table mean costs per sq. ft. of *wall* area of about 8*s.* 1*d.* and 7*s.* 8*d.* for the non-structural and load-bearing cladding respectively. This is a small margin and can only be increased in favour of the non-structural cladding by increasing the ratio of floor area to wall area. Within limits (say four storeys as a maximum) multi-storey building on the other hand increases the advantage of the load-bearing wall, since the extra costs of floor and roof slabs are distributed over a greater floor area and the permissible cost

of the light cladding, if it is to be competitive, must be reduced.

A related factor is the low cost of partitions (4·1 per cent of the total) which is chiefly explained by the division of the building into small separate blocks. This means that the cost of dividing walls which would be classified as partitions in a more condensed plan is borne by the external cladding. In a framed building this would result in an overall increase in cost, since external screens are intrinsically more expensive than internal ones, but in this case the extra cost is reduced by the use of internal and external load-bearing walls which, apart from their function as cladding and partitions, are carrying some of the structural costs as well.

It is evident that, as with the cladding components, the economy of partitions is very much bound up with the spatial organisation of the building as a whole. The conclusion may be drawn that where, as in the Darton design, subsidence risks demand extreme subdivision of the building, the reduction in the relative costs of cladding and partitions by using a multi-storey load-bearing wall construction can make a significant contribution to the low cost of the whole.

Finishes. Finishes are the next main category of components in order of average cost—they account for 10 per cent of the total. Floor finishes are the biggest item, with an average cost of over 3*s.* per sq. ft. including screeds and skirtings. Thermoplastic tiles cost from 2*s.* 6*d.* to 2*s.* 9*d.* per sq. ft. in Tables III, IV and V. The high cost in Table VIII is due to the use of special concrete tiles in the changing rooms and a hardwood strip floor in the assembly hall; that in the kitchen (Table IX) is accounted for by quarry tiles.

Wall finishes, with an average cost of about 1*s.* 7*d.* per sq. ft., are an item in which it would be difficult to make further economies. Costs higher than the average are found in the two-storey classrooms (Table III) where the walls are lined with fibreboard on battens, and in the kitchen (Table IX) due to the extensive use of glazed wall tiles. Lower than average costs occur in Tables V, VI, VII and X, where a large proportion of fair-faced brickwork has been used.

Ceiling finishes are a small item at Darton, with an average cost of just over 1*s.* per sq. ft. Fibreboard on battens is used where a lining of low thermal capacity and high sound absorption is required and costs about 1*s.* 2*d.* per sq. ft. The workshop block (Table VI) has virtually no ceiling finish as such, since the internal paint is applied directly to the underside of the woodwool roof. In the assembly group (Table VIII) the relatively high value of over 2*s.* per sq. ft. is due to the suspended ceiling in the assembly hall. It would probably be difficult to reduce these costs any further without detriment to the performance of the building.

Conclusion. The detailed analyses of the different groups of accommodation in the school set out in Tables III to XI are summarised in Table XIII, which tabulates the frame, cladding, carcase and total costs per sq. ft. of each group in order of increasing total cost per sq. ft. from the left. The average costs for the whole school are on the extreme right of the table. With these costs are set out certain other parameters indicating the performance and cost of the building. Among these are: (*a*) The cubic capacity calculated according to the standard method of measurement. (*b*) The average storey height given by dividing cubic capacity by floor area. (*c*) The area of floor enclosed by 1 sq. ft. of external wall. (*d*) The proportions of different kinds of wall cladding. (*e*) The net cost per cubic foot obtained from (*a*) above. (*f*) The approximate total net cost of each group of blocks.

The main trends revealed by this table may be summed up as:

(*a*) The low cost of the three groups containing two-storey blocks which appear on the left of the table.

(*b*) An irregular trend of increasing cost with increasing storey height.

(*c*) Within each of the two groups of two-storey and single-storey construction respectively, a regular trend of increasing cost with decreasing values for the area of floor enclosed by 1 sq. ft. of external wall.

(*d*) With one exception, a steady increase of carcase cost in step with total cost per sq. ft. The exception is group 5, the lavatory and cloakroom block, whose carcase cost is lower than that of the preceding group but whose total cost is higher because of its greater proportion of service and equipment costs (41 per cent against 33 per cent for group 4).

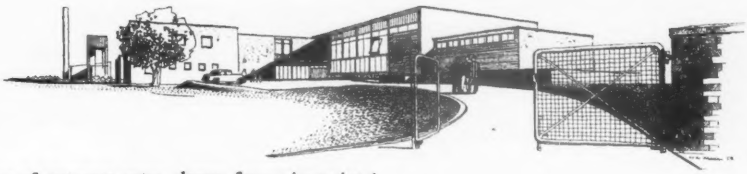
(*e*) The inconsistent behaviour of the costs per cu. ft., which in no way correspond to

Table XI

Group 9: Whole School. Blocks A to J inclusive. No. of Storeys: —. Floor Area: 28,303·6 sq. ft. Accommodation: —.

Category	Component	Cost per sq. ft.			
STRUCTURE	S1 Foundations	5/0·9		13/7·1 (22·8%)	28/1·4 (47·3%)
	S2 Frame	2/5·2			
	S3 Lintels	0/4·6			
	S4 Suspended floors ..	2/1·3			
	S5 Roof structure	3/7·1			
CLADDING	C1 D.P. membranes ..	0/7·4		12/1·2 (20·4%)	
	C2 External frames ..	3/7·2	8/11·0		
	C3 External panels ..	4/8·6			
	C4 External glazing ..	0/7·2			
	C5 Roof cladding	2/6·0			
	C6 Roof lights	0/1·8			
PARTITIONS	P1 Internal frames	0/6·0		2/5·1 (4·1%)	
	P2 Internal panels	1/9·2			
	P3 W.C. cubicles	0/1·9			
FINISHES ..	F1 Floor finishes	3/1·7		6/9·4 (11·5%)	
	F2 Wall finishes	1/7·5			
	F3 Ceiling finishes	1/0·8			
	F4 External painting ..	0/1·7			
	F5 Internal painting ..	0/9·7			
EQUIPMENT	E1 Cloakroom fittings ..	0/2·4		5/0·9 (8·5%)	
	E2 Built-in furniture ..	0/7·0			
	E3 Teaching equipment ..	0/1·1			
	E4 Ironmongery	0/3·7			
	E5 Sanitary fittings ..	0/8·0			
	E6 Cooking equipment ..	0/10·5			
	E7 Playgrounds, etc. ..	1/9·8			
	E8 Covered ways	0/6·4			
SERVICES ..	SE1 External plumbing ..	0/2·5		14/9·5 (25·0%)	
	SE2 Internal plumbing ..	0/9·5			
	SE3 External drainage ..	2/0·5			
	SE4 Heating installation ..	8/5·8			
	SE5 Electric installation ..	3/1·2			
	SE6 Gas installation ..	0/2·0			
CONTRACT	CON1 Prelims. and insurance	3/2·2		4/7·1 (7·7%)	
	CON2 Contingencies ..	1/4·9			
TOTAL ..		59/4·8		(100·0%)	

the trend shown by the costs per sq. ft. of the different groups. This is demonstrated particularly clearly by groups 1, 2 and 6, which have roughly commensurable areas (5,037, 5,939 and 5,632 sq. ft.), gradually increasing total costs (£13,755, £16,266 and £18,355) and total costs per sq. ft. (54*s.* 8*d.*, 55*s.*, 65*s.* 4*d.*); but whose cube costs in fact decrease in the same order (4*s.* 6*d.*, 3*s.* 10*d.*, 3*s.* 3*d.*). This anomaly is perhaps due largely to the presence of large single volumes in groups 2 and 6 (small hall and assembly hall respectively) but does show how unreliable cube costs can be in indicating value for money.



View of entrance gates, drawn from viewpoint 1

(*f*) Lastly, and perhaps most important, the table shows how wide a variation may be masked by average costs for a complex building. A range of 23*s.* 2*d.* to 61*s.* 5*d.* for carcase costs per sq. ft. with a mean value of 28*s.* 1*d.* demonstrates how great the need is for precision in cost control in these circumstances.

A fact which emerges most clearly from this study is that a constructional method

Table XIII—Summary of Analysis

		Groups in order of Increasing Total Cost per sq. ft.*								
		Two-storey			Single-storey					
Group		1	2	3	4	5	6	7	8	9
Space		Class	Class/ Assembly	Class	Service	Service	Assembly	Service	Service	Whole School
Blocks		P, L	E, F	M, N, O	K	Q	A, B, C, D	G, H	J	—
Analysis Table		Table III	Table IV	Table V	Table VI	Table VII	Table VIII	Table IX	Table X	Table XI
Accommodation		Class-rooms	Small Hall, Entrance, Library, Admin.	Class-rooms	Work-shops	Lavatory and Cloaks	Assembly Hall, Foyer, Changing rooms	Kitchen	Boiler-house	
Floor area (ft.^{2}) Percentage of Total		5,037·0 (17·8)	5,939·1 (20·9)	4,025·3 (14·2)	2,204·9 (7·8)	1,800·4 (6·4)	5,632·2 (19·9)	1,860·3 (6·6)	964·4 (3·4)	28,303·6 (100·0)
Cube (ft.^{3})		60,900	83,700	49,740	28,510	23,170	112,245	27,495	19,255	344,115
Average storey height (ft.)		12·1	14·2	11·1	12·9	12·9	20·0	14·8	20·0	12·2
Area of floor enclosed by 1 sq. ft. of external wall (ft.^{2})		0·85	0·83	0·81	0·96	0·94	0·72	0·72	0·44	0·88
No. of storeys		2	1 and 2	1 and 2	1	1	1	1	1	—
Load-bearing structure		Walls only	Mixed walls and frame	Mixed walls and frame	Mixed walls and frame	Walls only	Mixed walls and frame	Walls only	Mixed walls and frame	—
Percentage areas of wall cladding	Percentage glazed	19·0	12·4	18·2	18·7	11·6	22·0	5·4	7·9	—
	Percentage non-structural	20·3	17·2	30·1	34·3	—	40·5	—	10·8	—
	Percentage load-bearing	60·7	70·4	51·7	47·0	88·4	37·5	94·6	81·3	—
Net costs per sq. ft. of floor area	Frame—Category S2	—	3/0·5	2/6·0	2/8·5	0/7·9	4/7·1	—	13/0·7	2/5·2
	Cladding—Categories C2 + C3 + C4	8/9·1	6/10·0	8/6·0	8/1·4	7/8·3	11/1·0	7/10·9	20/11·3	8/11·0
	Carcase—Categories S + C + P Percentage	23/1·8 (42·3)	25/9·6 (47·1)	26/5·0 (48·2)	29/0·6 (49·2)	27/6·2 (43·6)	33/2·1 (50·8)	35/5·9 (39·8)	61/5·0 (68·2)	28/1·4 (47·3)
	*Total—All categories	54/8·3	54/11·6	55/0·3	57/10·3	63/1·9	65/3·9	89/1·0	90/2·9	59/4·8
Net cost per cu. ft.		4/6	3/10	4/11	4/6	4/11	3/3	6/–	4/6	4/11
Approximate total net cost		£13,755	£16,266	£11,065	£6,384	£5,655	£18,355	£8,255	£4,325	£84,060

which has been shown to be economic for one building may be very inefficient indeed when applied to a building of different plan form and spatial organisation, and that therefore the ways in which a good economy has been achieved at Darton will be applicable only to those buildings with an analogous plan and comparable site conditions. The subdivision of the building and dispersal of the plan which have been demanded by the severe subsidence risks are both essentially expensive measures, giving high service costs and a large proportion of external wall in relation to floor area. But, with the above reservations in mind, it is possible to conclude that high costs due to these measures have been offset by the use of rectangular plan forms of simple outline and reasonably square proportions, by the economic planning of each block with a high proportion of usable floor area, and by the use of two-storey construction for 40 per cent of the total floor area. These factors have ensured as high a ratio of floor to wall area as circumstances permit. Further economies have been achieved by the use of load-bearing wall structures, which seem to be specially economic in this kind of situation.

Throughout the development of this project the following aims have been kept in mind:

1. To attempt to design and construct a boys' secondary modern school at a cost well within the current limits applied by the Ministry of Education, including (*a*) The cost of structural precautions taken against the liability of damage due to mining subsidence. (*b*) The additional costs necessarily incurred during the first phase of building in order that the ultimate development of the school shall be planned in the most economical manner. (*c*) The provision of good interior and exterior finishings to keep maintenance costs at the lowest possible level. (*d*) The intention of planning a building and developing its architectural character from the idea of the small structurally separate blocks required by its being in an area liable to mining subsidence, instead of providing a conventional solution broken up by structurally complicated and concealed joints. (*e*) The provision of adequate garden and landscaping works to enhance the outlook from the building in an industrial area.

2. To study the question of using structure and building methods which will give rapid and economical construction, and to use structural methods best related to the solution of particular problems. By planning in isolated blocks this can be more easily achieved and the question of architectural integration rendered simpler.

3. To use materials and methods familiar to the building trade in comparison with other systems at present in use, and to examine their relative economy and speed of erection. Over a period a comparison of their relative maintenance costs may also be built up.

4. To attempt to devise a method of cost analysis applicable to conditions encountered in the West Riding of Yorkshire, and from that point to investigate the question of cost planning.

The report is of an explanatory nature and has been published as a description of work in progress rather than a statement of firm conclusions.

The following members of the Quantity Surveying and Engineering Staff of the County Architect's Office collaborated in the design of the building:—

Estimates. W. Pepper, A.R.I.C.S.
Structure. G. Mundy, B.Sc., A.M.I.Struct.E.
Heating. T. E. Cunningham, M.I.H.V.E.
Electrics. B. Davies, A.M.I.E.E.

Table XII

Assumptions—(*a*) Single-storey building.
(*b*) U value of about 0·3 for both systems.
(*c*) 20 per cent of wall area glazed.
(*d*) 0·9 sq. ft. of floor area to each sq. ft. of wall.

	Cost per sq. ft.	
	Non-structural cladding	Load-bearing cladding
Structural frame (S2)	3/- (3 lb./sq. ft. at £112/ton)	—
Roof structure (S5)	4/- (short span slabs)	6/- (long span slabs)
Roof cladding (C5)	2/- (no screed)	3/6 (including screed)
External wall cladding (C2 + C3 + C4) ..	9/-	8/6
	18/-	18/-

The perspective drawings for this article were done by Mr. H. N. Mason [*A*]

Correspondence

MATERIALS AND TECHNIQUES

The Editor, R.I.B.A. Journal.

DEAR SIR,—Mr. Mills is away and unable to join me in a reply to Mr. Rosner's letter. In his absence I offer the following comments.

The automatic climbing shuttering Mr. Rosner refers to was included because it seems a worthwhile line of attack on the high costs of shuttering for buildings like flats, where floor plans can repeat above one another, but not as an example of a typical German method. I think Mr. Rosner is in error about the 118 operatives who he says were needed day and night to raise the shuttering, but possibly the total number of men in the building reached about this number at one time. The floors were constructed by traditional methods out of character with the rapid walling system, and some further developments probably need to be sought. Details of this building are being reviewed in this country.

We are glad to have Mr. Rosner's support for our view that some kind of cladding other than rendering is worth developing for no-fines buildings. There is no answer to his question about how costly this might be, because it has not been developed yet.

The buildings we mentioned and illustrated as being 8 or 9 storeys high in clay block construction about 9 in. thick come mainly from Sweden, Switzerland and France, though there are slightly greater thicknesses at a few strategic points in lower floors, but this does not invalidate the general picture we described. Certainly the diagram Mr. Rosner shows, which suggests that four storeys might be the usual limit to be carried on this thickness in Germany, does not represent the limits actually achieved. Room spans are normal and there is no special stiffening of walls, but the structure as a whole is, of course, a proper engineering design.

The other interesting items Mr. Rosner mentions were of a type we excluded from our discussion as not being near enough to our main subject.

Yours faithfully,

W. A. ALLEN [*A*]

BILLS OF QUANTITIES

SIR,—We heartily endorse Mr. R. P. Smith's letter in the last issue of the JOURNAL. We consider that it is high time that Bills of Quantities should combine with an easily understood specification in one document. Could not the R.I.B.A. and the R.I.C.S. consider this matter in a joint *ad hoc* committee?

Yours faithfully,

PICTOR, SNAILUM AND HUGGINS [*F/AA*]

Photograph of the model of the whole scheme of which the first part is now in use and the second under construction

B.B.C. Television Centre Scenery Block, White City, Wood Lane

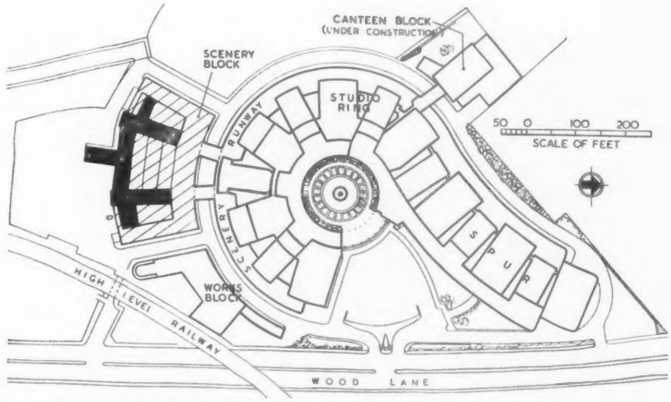
Architects: Norman and Dawbarn [*FF*] in association with M. T. Tudsbery, C.B.E., M.I.C.E., B.B.C. Consulting Civil Engineer

General. The project of the B.B.C. Television Centre at the White City involved planning just over half the 13-acre site for the needs of the Centre, leaving the remaining half unplanned until later experience should enable the B.B.C. to decide on the necessary development, but the architectural conception of the half-site had necessarily to take into account the development of the site as a whole. The plans here reproduced show the curvilinear 'tail-piece', or spur, which will provide the flexibility necessary for the planning of the second half of the site when the detailed requirements are known.

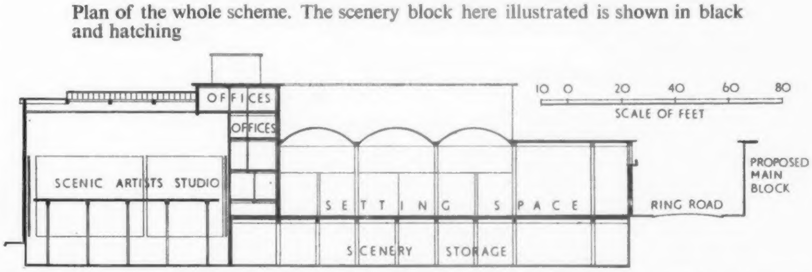
It is now envisaged that this tail-piece shall provide not only more studios but also a large garage, a block of rehearsal-rooms and possibly a roof heliport.

The main entrance to the Centre will be in Wood Lane with a secondary entrance in Frithville Gardens, which lead to the B.B.C. television studios in Lime Grove. There will be parking space within the curtilage of the site for all cars using the Centre.

The main studio block will consist of a multi-storey ring providing accommodation for dressing-rooms, wardrobe service, engineering and offices, the central portion of the ring being a circular garden 150 ft. in diameter. Television production studios and their ancillaries will radiate from the ring, together with telecine and telerecording areas, a central control room and two 'presentation' studios for the insertion of announcements and captions. A continuous runway will enclose the outer periphery of the studios so that units of scenery and properties can be taken from



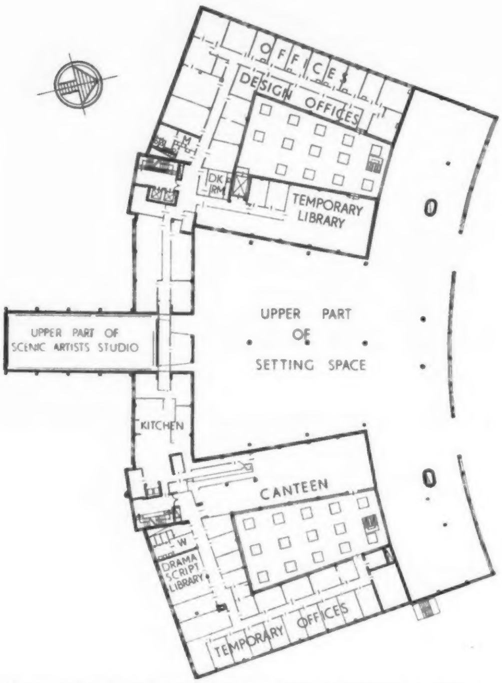
Plan of the whole scheme. The scenery block here illustrated is shown in black and hatching

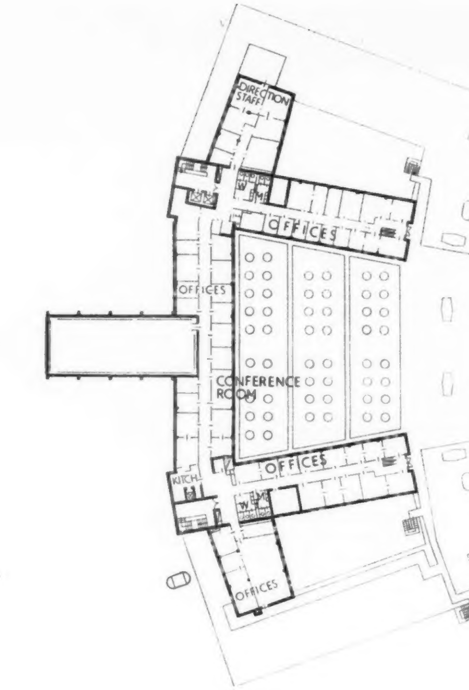


The section through the scenery block illustrates the process of production. Finished scenery is dispatched by lorry in the ring road

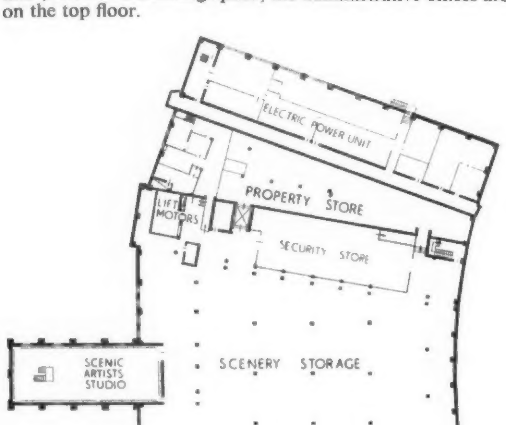
the scenery block direct to the studios; these services being thereby segregated from areas allocated to artists.

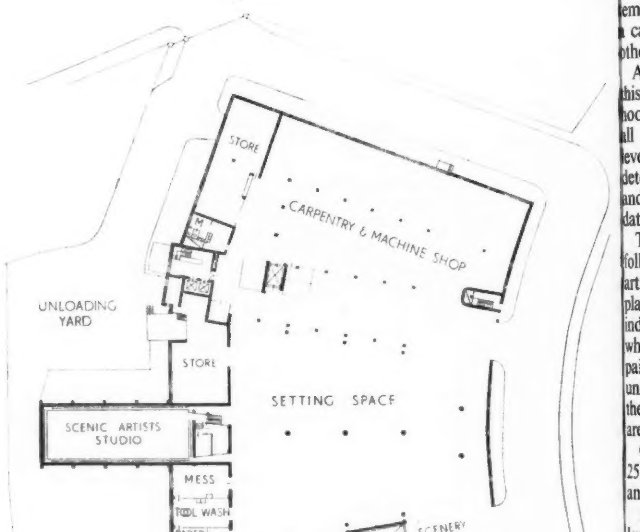
Work has recently started on the canteen block. For the present it will be divided for rehearsal purposes, but when the main block is occupied the canteen will be equipped to serve 750 persons at one sitting. It will later be connected with the main block by a tunnel and also by a





Above: the first floor plan. Right: the second floor plan. Generally, the technical and design offices are on the first floor, close to the setting-space; the administrative offices are on the top floor.





Above: the basement. Right: the ground floor. The scenic artists' studio is 65 ft. high and is for the painting of large backcloths. The various units are planned to serve the central setting-space, where the stage sets are assembled

ridge across the road outside the scenery unway.

The works block will contain workshops or the maintenance and repair of technical equipment, as well as accommodation or the building maintenance staff. There will also be an experimental laboratory where lighting and optical effects can be ried out.

he **Scenery Block.** This building covers pproximately one acre and is the first part f the project to be completed; it has been esigned to take its place as a unit in the eneral architectural conception. It conains extensive workshops for carpenters, roperty makers, scenic artists and others ngaged in making scenery for studio roductions. There is also a 26 ft. high etting-space where scenery is assembled, ogether with large areas for storage of cenery and properties which are suitable or re-use. In addition, the block contains 00 offices for the use of administrative taff, producers and designers; there is also temporary canteen for the occupants of he block until the main block is built.

This scenery block is not intended to tand on its own; ultimately it will take a ubsidiary place in a much larger coneption, but the planning had to take into ccount the need for many more offices han originally envisaged (which resulted n an additional office floor), and also the emporary inclusion of further offices and canteen until these become available in ther blocks.

After assembly in the setting-space in his block, scenery will be taken under oods to the scenery runway and thence to ll studios throughout the scheme. The evel of the setting-space was therefore determined in relation to the whole lay-out, and the other floor levels followed from the datum of +32 thus set.

The main planning components are as follows: Basement, varying levels. Scenic artists' studio, 65 ft. clear height, with a platform 73 ft. by 24 ft. at the 32 level and independent of the surrounding walls, on which guides are mounted to support painting frames. Boiler-house and power unit, each capable of expansion to serve the whole scheme. Main scenery storage area.

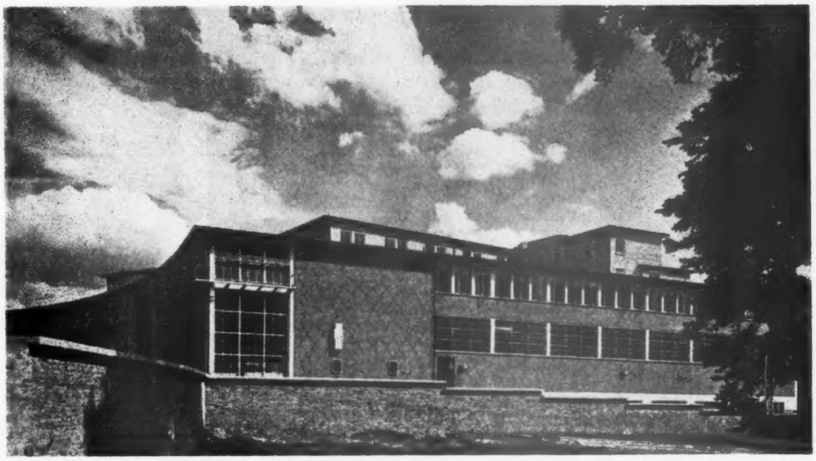
Ground floor, level 32. Setting space, 25 ft. clear height, with workshops, stores and a mezzanine at level 49.

First floor, level 61, and second floor, level 71. Permanent offices.

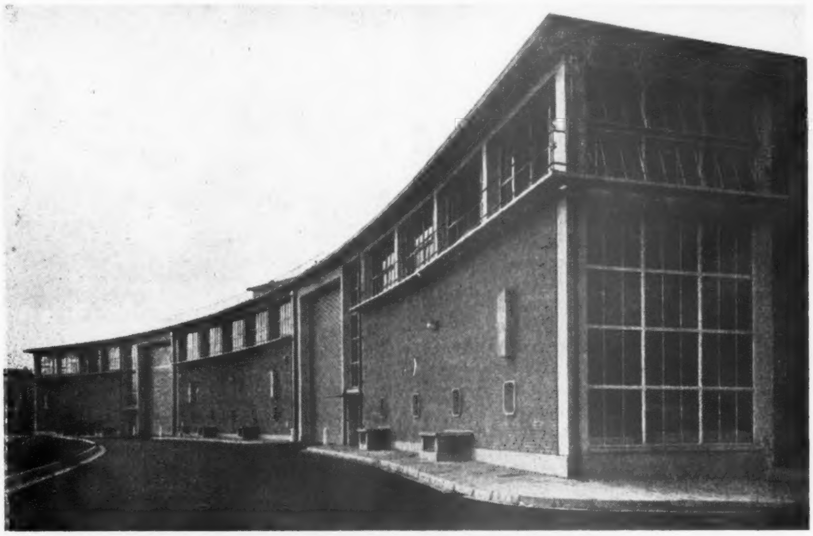
The offices can be reached by a separate entrance, and apart from these the building is basically a workshop and has been treated as such.

An electrically-operated hydraulic lift has been installed to enable large sections of scenery to be moved; the lift is 30 ft. by 19 ft. by 15 ft. clear height and it connects the basement and ground floor. The doors under the hoods which will connect the setting-space with the main block are 25 ft. high and 18 ft. wide.

Sprinklers, shutters and other fire precautions have had to be installed as the building contains cells exceeding the maximum permitted under the London



The side of the building showing the carpentry and machine shop on the ground floor with offices on the first floor



The dispatch side of the scenery setting-space showing the two lorry doors

Building Acts. When escape is possible across the tops of the hoods to the main block the temporary escape staircase on the east side of the building will be removed.

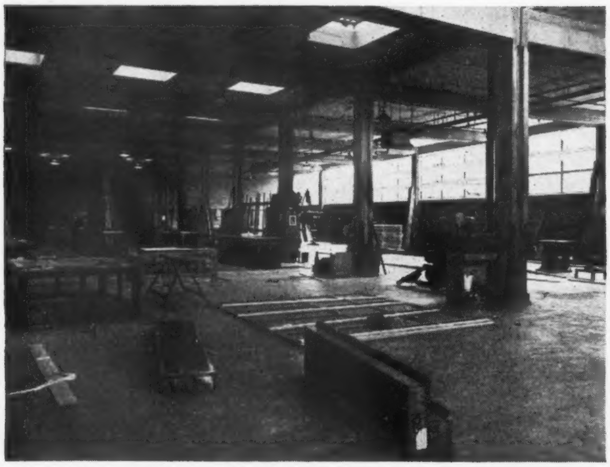
At varying depths the ground is humus and fill on brown clay, on gravel and sand and on blue clay. As the brown clay could not be relied on to carry the desired loading it was replaced by sand and gravel from deeper excavations. The basement is necessarily at different levels and loading was calculated to give as uniform a settlement over the whole building as possible. Well points were used wherever it was necessary to excavate below the water table at about level 11.

The basement is completely tanked up to ground level with reinforced concrete floors and walls, except for certain lengths of wall where possible extension has been planned. The earth and water pressures on the basement walls are transferred to reinforced concrete piers by 12 in. thick

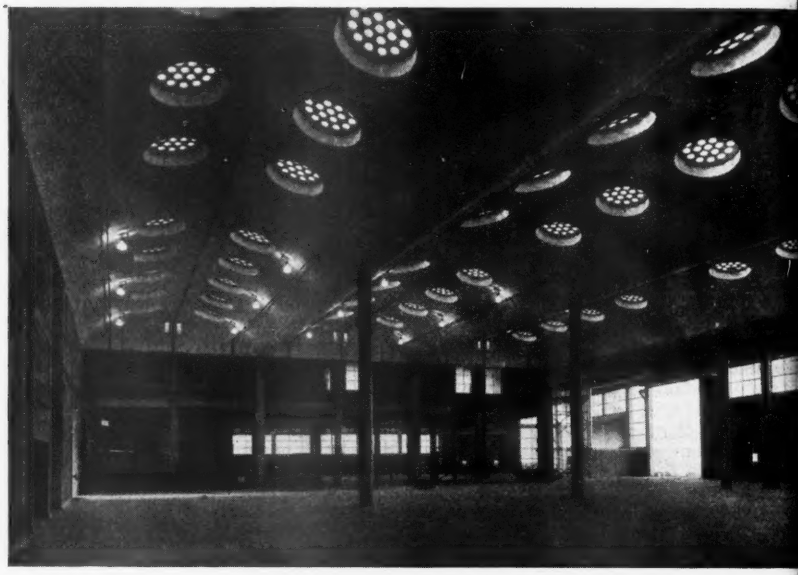
The south-west corner

reinforced concrete panels. The piers act as propped cantilevers; the action at the top being transferred to the ground floor slab and framing.

The structure as a whole is steel-framed,




Above: the carpenters' and machine shop where units of scenery are shown being assembled



Right: the central scenery setting-space is barrel-vaulted in reinforced concrete. Below, the 65 ft. high studio. The floor is independent of the walls so that scenery 'flats' can be raised and lowered in slots for painting. Control is electric from a panel in the middle of the floor. Bottom right: the property store which has steel shelving


ntrance hall and enquiry desk

A scene designers' room

he temporary library

The canteen

he office of Sir George Barnes, Director of Television Broadcasting

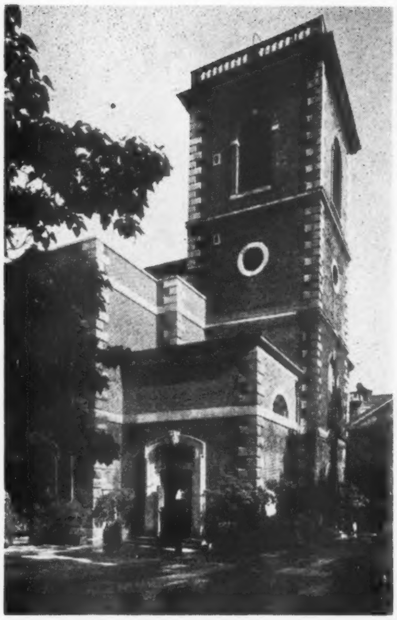
The conference room

he outer stanchions being carried on the ops of piers in the basement walls. Vhere heavy loading is required the uspended floors are of *in situ* reinforced oncrete; elsewhere they are of pot onstruction.

In the scenic artists' studio, with its clear height of 65 ft. from floor to roof beams, prestressed precast concrete columns have been used, and these are designed to resist horizontal wind loads as cantilevers.

The external walls generally are 12 in. cavity, faced with two types of bricks, the selection being influenced by the question of availability during the erection of the whole scheme.

The scenic artists' studio is roofed with metal decking and contains a lantern. The roof over the 26 ft. high setting-space is in barrel vault construction.



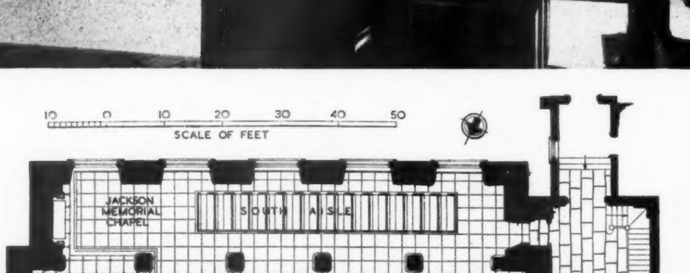
St. James's Piccadilly Repaired

Architects: Richardson and Houfe [*FF*]

WREN'S LARGEST CHURCH, consecrated in 1684 when he was 52 years of age and at the height of his powers, was extensively damaged by fire caused by incendiary bombs on 14 October 1940. It has now been repaired under the direction of Professor A. E. Richardson, R.A. [*F*].

Wren seems to have been very pleased with this church because he had created an auditorium, where more than 2,000 persons could hear the preacher, at the remarkably low cost of £8,500. He said of it, '. . . the whole Roof rests upon the Pillars as do also the Galleries; I think it may be found beautiful and convenient; and as such the cheapest of any form I could invent'.

In another context he explains his intentions more fully and, incidentally, gives us a mental picture of the architect observing with satisfaction a building which he has created functioning as he intended it should: 'I can hardly think it practicable to make a single room so capacious as to hold above 2,000 Persons, and all to hear the Service, and both to hear distinctly, and see the Preacher. I endeavour'd to effect this, in building the Parish church of St. James's, Westminster, which, I presume, is the most capacious, with these Qualifications, that hath yet been built; and yet at a solemn Time, when the Church was much crowded, I could not discern from a gallery that 2,000 were present.' What architect of a public building has not sat unobserved among the audience, studying the way in which his building 'worked', while paying but scant attention to the proceedings?



The 'single room' measures 88 ft. b
62 ft. The beams supporting the three-side
gallery are carried on piers, above which

The vestibule and north wall. The doorway has been renewed and the roof of the vestibule lowered

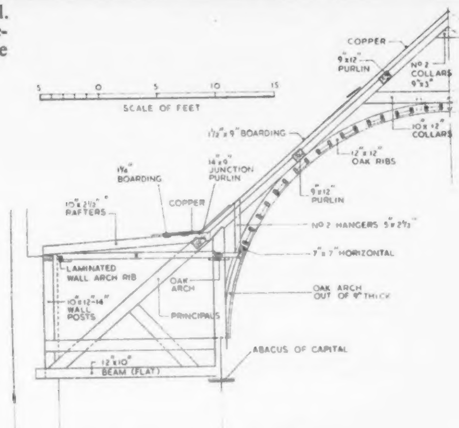
re solid pine columns taking the greater art of the roof load. As designed by Vren, the building had a square tower at he west end and a doorway in the centre f the south side. A spire was added arly in the 18th century and in 1856 the riginal gallery stairs were removed and wo vestibules added at the west end. therwise the building remained subtantially as Wren had designed it.

The fire destroyed the greater part of he roof. Fortunately the magnificent altar iece and organ case, both attributed to Grinling Gibbons, were saved; the altar piece had been sandbagged early in the war on the advice of Professor Richardson.

When the building was examined so hat the repair work could be started it was found that the north wall of the church was badly cracked and leaning outwards. The wall still leans but has been underpinned and strengthened with a framework of reinforced concrete. This was one of those jobs which is difficult, and indeed perilous, to execute but which ends by leaving the structure looking exactly as it did before.

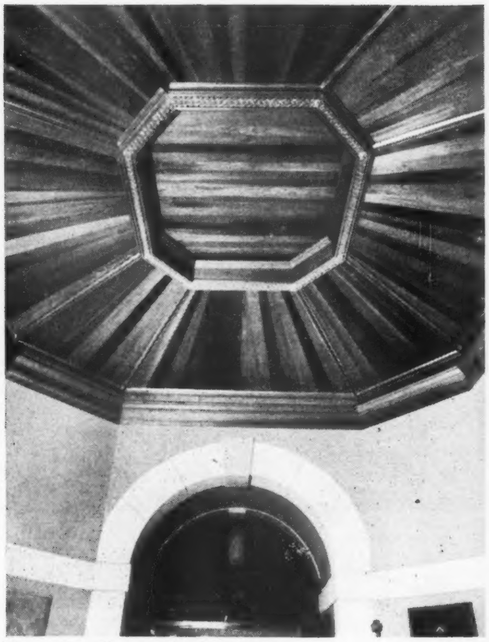
The roof with its plaster vaulting has been entirely renewed, Wren's original construction and plaster decoration being reproduced almost exactly, though the outer roof surface is now of copper. The pine columns were discovered to be quite sound and are now once more performing their task. New leaded lights filled with crown glass have been provided in the windows. The east window is the work of Mr. Christopher Webb.

Looking at this magnificent interior, bright with gilding on plaster and oak mouldings and flooded with light, one feels that Professor Richardson has recaptured



Part section of the roof construction

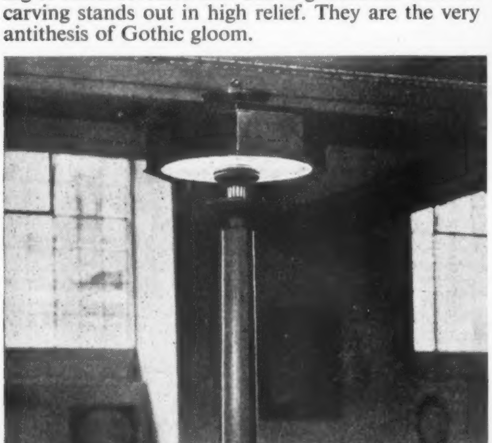
Photographs of the interior give but a poor impression of its sparkle and crispness. In two senses a new light is thrown on Wren's architecture by clean detail and clear glass

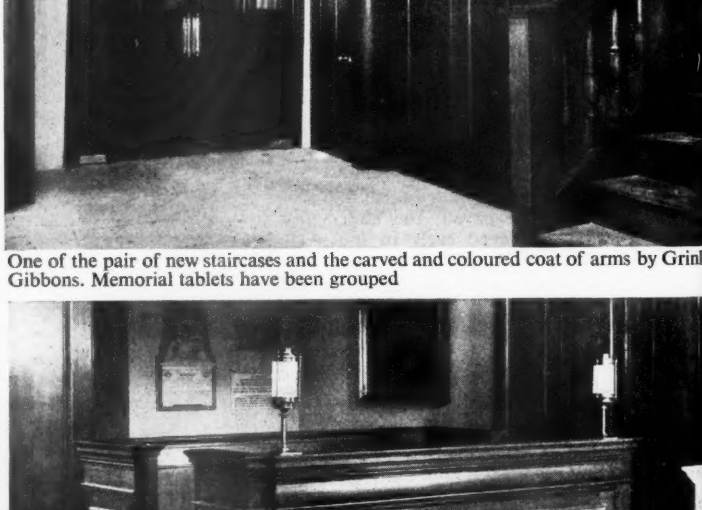


The new ceiling under the tower

One of the pair of new staircases and the carved and coloured coat of arms by Grinling Gibbons. Memorial tablets have been grouped

the original quality of Wren's 'single room'. One realises also the extent to which many of Wren's churches have suffered from London grime and ill-considered Victorian memorial windows. These Protestant-Classic churches demand abundant light; with it, their crisp mouldings are clear cut, the figuring of oak is revealed and Grinling Gibbons' delicate carving stands out in high relief. They are the very antithesis of Gothic gloom.





Above, one of the new lamps. Right, a clergy pew

The Vacuum Concrete Process

By Geoffrey K. Twibill, B. Arch.(Sydney) [*A*]

An advance in technique employing the latent force of atmospheric pressure to improve all the desirable characteristics of concrete

A SIMPLE PHYSICAL PROCESS which permits water to be removed quickly, subsequent to the placing of an easily-worked concrete mix, is a recent and notable development in the science of building.

According to the chemistry of concrete, a given quantity of cement requires a precise quantity of water to set up the hydration process forming a colloid of optimum strength. It is this colloid which binds together the inorganic ingredients of concrete. Any excess water causes a weakening of the colloid, delays the time required for initial strength to be obtained, and limits the ultimate strength of the concrete.

On the other hand, since workability and ease of pouring have to be borne in mind, far more water than the chemistry of the subject demands is invariably used. In practice, therefore, concrete is weaker than it need be, or conversely, more cement is used than is chemically necessary for a given strength.

The vacuum process was first demonstrated a few years prewar at Yale University and has subsequently been investigated extensively on the Continent: it is now being introduced in the British Isles.

Shutters no longer play a passive role of long duration in retaining the plastic mass, but do active short-time service by providing the means of extracting excess mixing-water. In order to adapt conventional shuttering for this purpose, it is lined with a sealed filter, known as a 'vacuum mat,' which creates a thin air-chamber over its surface. Immediately the concrete is poured, the surrounding air is extracted so that the concrete is enclosed by a (partial) vacuum. The net difference between residual vacuum pressure and atmospheric pressure acting on the concrete compacts it under a steady force of more than $\frac{3}{4}$ of a ton per sq. ft. The result is the rapid expulsion of water or, more precisely, the forced percolation of interstitial fluid towards the areas of low relative pressure.

Atmospheric compression alters the internal structure of the concrete, causing the solid elements of the skeleton to approach nearer to each other before the set. Thus a good proportion of the shrinkage associated with setting concrete takes place while the concrete is fresh.

Monsieur Leviant, pioneer of the vacuum process in Europe, describes the phenomenon thus: 'In a given zone of fresh concrete, the total pressure is the resultant of an intergranular pressure (direct contact pressure borne by the aggregates) and a fluid or interstitial pressure. . . . This total pressure . . . counterbalances the total load —atmospheric pressure plus self-weight of concrete above the zone considered. Intergranular pressure is generally low in relation to interstitial pressure. Under vacuum a profound change in the distribution of pressures is brought about. The interstitial fluid pressure . . . is reduced to almost nothing and, since the total load has not changed, the intergranular pressure increases considerably. . . . The skeleton must bear what the fluid no longer supports. The solid elements of the skeleton . . . approach nearer to each other and the concrete contracts . . . a mechanism similar to the shrinkage in course of setting with the difference that the concrete is in the fresh state. Through compaction and concentration, particles of cement in suspension . . . are brought together to the point of forming a "micro-skeleton"—a structure not unlike that which, in the concrete, is formed by the aggregates. Thus at the end of the vacuum process the concrete has a dense composite skeleton formed of both aggregates and cement particles.'

Processing times depend on such variables as the thickness of the concrete under treatment, the richness of the mix, and the initial water/cement ratio, but rarely need exceed 30 minutes. Nor is there any risk involved in prolonged treatment. The vacuum process cannot be overdone. When the skeleton has reached its most compact random arrangement, the expulsion of water ceases automatically. In practice, sufficient water always remains for complete hydration of the cement.

Immediately the processing vacuum is released, an infinite number of minute menisca are formed on the fresh surface, and the concrete acquires a compressive strength of up to 20 lb./sq. in., which is sufficient to retain its shape without fear of damage or deformation. The menisca play the part of anchorages, effecting a general capillary tie and holding together the skeleton of the aggregates—similar in effect to prestressing. Shuttering may be safely removed from walls and columns 18 ft. high only 30 minutes after pouring and, furthermore, may be re-used at once.

The phenomenon of self-support, known as 'pseudo-solidification,' quickly introduces into the life of the concrete, between the phase of the fluid mass and the solid set, a new phase which offers the builder a wealth of opportunities. (Fig. 1.)

The comparative increase in compressive strength of vacuum-treated concrete and of the same concrete untreated is 100 per cent in the course of the first seven days. The 28-day strength is reached in about ten days (Fig. 2). For the same strength after 80 days, the cement content need be only 70 per cent of a similar untreated concrete. Thereafter the ratio changes only slightly and an ultimate strength increase of not less than 25 per cent may be relied upon (Fig. 3).

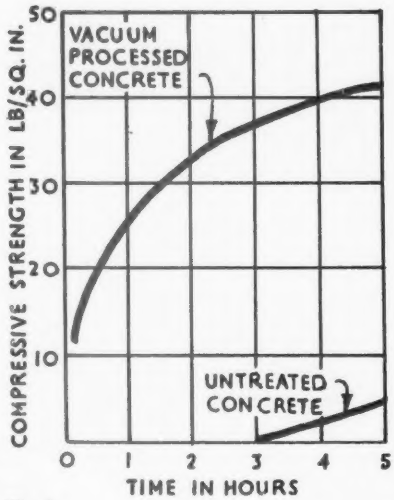


Fig. 1.

Equipment. The essential equipment for the process consists of vacuum mats connected, through pipes or hoses and a gravitational water separator, to a vacuum pump.

The Vacuum Mat consists of an airtight cover round the under edges of which a rubber seal is fixed. The cover in most cases is rigid, eliminating the need for conventional shuttering.[1] Beneath the cover is placed a sheet of expanded metal and a mesh of fine wire gauze or, alternatively, finely perforated sheet-metal. The wire gauze or perforated sheet-metal is covered with a filtering fabric, usually linen, which is the surface that comes in contact with the concrete being processed. The function of the expanded metal and the gauze is to form a passageway for the escape of water by preventing the filter fabric and the cover, which form the vacuum chamber, from collapsing. If the cover is designed with a suitable system of passageways, the expanded metal can be omitted. The linen filter fabric, provided it is regularly hosed, may be re-used up to 200 times, which is more than compensation for the fact that there is no need for oiling as with conventional passive shuttering.

The Vacuum Pump. A 7 h.p. motor is capable of operating a suction mat having a perimeter of 50 ft. which is sufficient for most purposes. In the case of large-scale multiple processing, a vacuum main with numerous take-off points is laid to the works from a central exhauster. In either case the vacuum pump generally represents an investment no more than that of the

[1] A flexible vacuum mat is suitable for the treatment of slabs and for the 'activating' of passive shuttering. It is claimed that the additional unit cost of the latter modification does not exceed more than a quarter of the original outlay on shuttering.

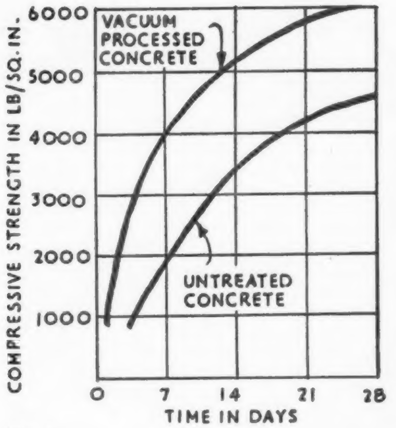


Fig. 2.

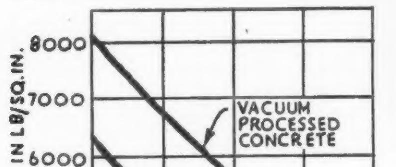


Fig. 3.

common compressor. Thus the 'vacuum unit' is becoming a familiar item, in the same way as the compressor, both on the job and in the builder's casting yard.

The Vacuum Process for Slabs. Directly after the pouring and screeding operation, vacuum mats are laid and activated. At the conclusion of treatment, usually about 15 minutes, atmospheric pressure has compacted the slab to the extent that footprints do not show. The pseudo-solidified concrete can be readily worked after processing to produce a perfect monolithic surface without the necessity for a subsequent topping operation, except for special finishes. Vacuum-treated surfaces, moreover, are free from blows and bubbles, wear resistant, non-dusting, virtually impervious and, due to reduction in shrinkage, are not subject to cracking and require fewer construction joints (Fig. 4). The economy in shuttering for suspended floors, roof slabs and shells results not from pseudo-solidification as with walls and columns, but from accelerated hardenings: the supporting shuttering can be removed much earlier ($\frac{1}{3}$ to $\frac{1}{2}$ the customary time). Provided the slab is no thicker than 8 or 9 in., no advantage is gained in processing from underneath. In any case the vacuum mat would very likely be damaged during the placing of the reinforcement and of the concrete, and it could not be removed until the concrete had set hard—thereby defeating its principal advantages.

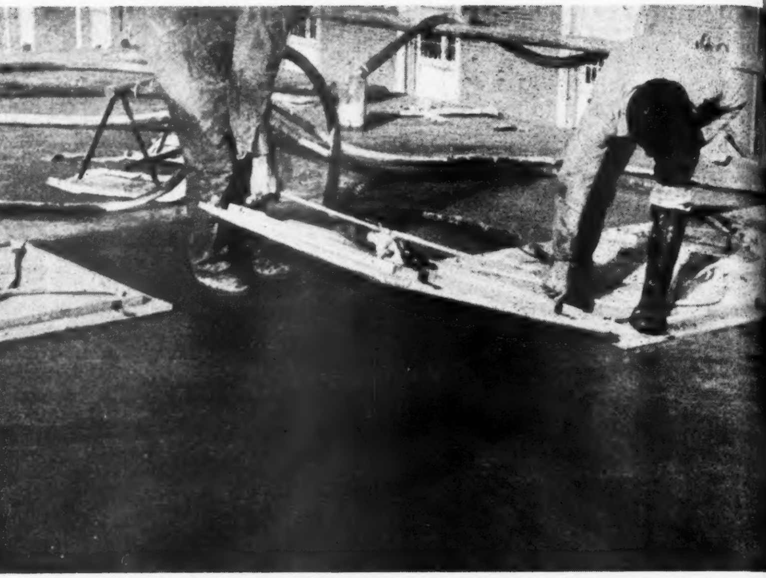


Fig. 4. A vacuum-treated surface. The workman on the left is walking on the fresh concre[te] without leaving footprints.

Vacuum Topping of Worn or Damaged Surfaces. The vacuum process has proved most beneficial in the application of thin granolithic and other finishes where trouble is so frequently met through shrinkage and insufficient bond between the topping and the parent slab. Atmospheric compaction assures a finish in all respects equal to that obtained in the vacuum processed slab, though it is desirable that joints be made over those existing below. A process time of no more than 10 minutes is sufficient. It is common practice on the Continent to give the topping a surface pattern through placing a suitably formed perforated metal sheet immediately under the filter cloth.

The Vacuum Process for Beams. Beams are processed from the sides. The vacuum mats are stripped immediately after treatment, though the soffit shuttering must remain in place (as was the case with slabs) for a comparatively short time.

The Vacuum Process for Walls and Columns. The principal economy of the vacuum process applied to *in situ* work is that it enables shuttering for walls and columns to be struck immediately after a short processing period and to be re-used at once. Furthermore, the shuttering requires no more than a few positioning struts. By arranging the vacuum mats in independent horizontal lifts, each of about 2 ft., processing can proceed simultaneously with the pour. Pouring is carried out continuously, the vacuum being applied to each succeeding lift as soon as the concrete level covers the appropriate seal. Thus horizontal thrust is progressively suppressed, never much exceeding one lift and at the same time the shuttering is firmly held t[o] the concrete by atmospheric pressure—replacing the need for strutting (Fig. 5).

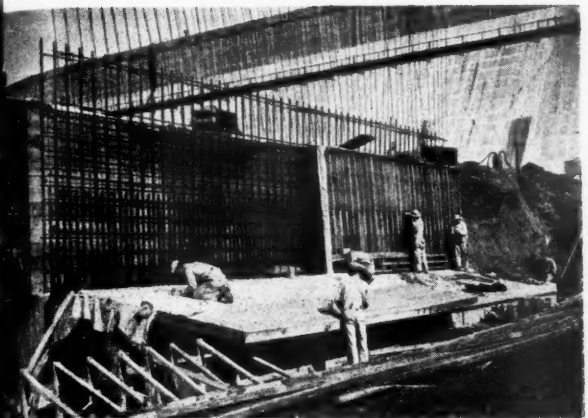
For high walls, structurally independe[nt] lift-shafts and the like, a system of climbi[ng] shuttering may be employed, thus: lift 'A['] being in place, concrete is poured to th[e] height and the treatment commenced. A[s] soon as this strip is under vacuum, lift 'B' is poured and the treatment commence[d]. In the meantime, lift 'A' has pseud[o-]solidified, and the active shuttering h[as] been stripped and positioned above lift 'B' . . . and so the work is continued. For lon[g] lengths of lift it is advantageous to wo[rk] in 'waves' (for walls) and 'spirals' (f[or] shafts, etc.).

As with floors, surfaces of walls an[d] columns can be finished as work procee[ds]. Stucco and similar renderings may b[e] applied, if necessary, immediately aft[er] processing with the assurance of a perfe[ct] bond. Other forms of surface finis[h] usually associated only with precast wo[rk] and obtained, for example, by wi[re] brushing, scraping or hosing before the se[t] can now be carried out on *in situ* concre[te] shortly after the vacuum mats are remove[d].

The Vacuum Process for Precast Work. I[n] the precasting industry, too, the vacuu[m] concrete process is finding its place in bo[th] field and factory. The greater early streng[th] of a vacuum-processed product permi[ts] earlier handling, thereby conserving stora[ge] and curing space, moulds and often rei[n]forcing steel (Fig. 6).

Combination of Vibration and Vacuum. Th[e] combination of vibration with the vacuu[m] process is desirable. Simultaneous pressu[re] and vibration improves the beneficial effe[ct] of either treatment applied singly.

In the course of mixing and pouring, a[ir] is invariably entrapped in concrete. Whi[le] surface bubbles are quickly expell[ed]



ig. 5. Shuttering for a canal wall.

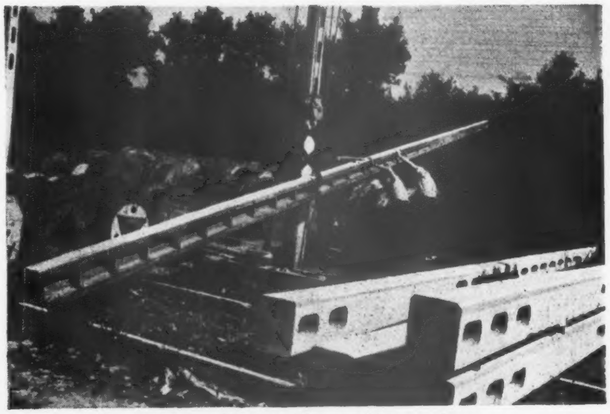


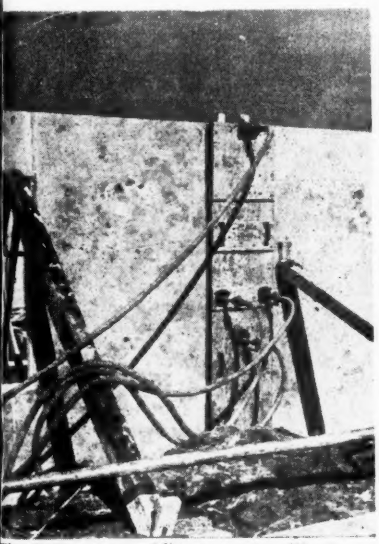
Fig. 6. Lifting a telegraph post 48 hours after pouring.

hrough the filter, vibration remains the ole means of removing internal bubbles. t is effective, too, in driving excess water owards the surface, thereby supporting the ction of the vacuum. Vibration should ease, however, well before the processing acuum is cut.

acuum-Operated Equipment. Various devices, other than for the actual treatment of resh concrete, are associated with vacuum oncrete technique by virtue of the fact hat they use the same form of energy.

Shuttering may be positioned by a ystem of 'vacuum holders' each consisting f a pressed steel plate or plywood board itted with a peripheral rubber seal. When vacuated (at the turn of a valve) they are mmediately held on any hard and reasonably flat surface by the force of atmospheric ressure, greatly simplifying strutting and educing erection time.

Precast wall units have been 'vacuum elded' through the use of mats with built-in holders at the sides. As the treated concrete of the joint has negligible shrinkage and excellent bond, the main cause of cracking between precast units is eliminated (Fig. 7). This form of vacuum mat with integral holders seems likely to be instrumental in the development of large structures built on the principle that a self-supporting precast concrete frame, prestressed where necessary, may be combined with concrete poured in situ to support the required working load, at the same time practically eliminating conventional scaffolding and formwork and providing in addition an easily-finished concrete surface.



ig. 7. Vacuum-welding precast wall units.

Handling of precast slabs and shells can be greatly facilitated by the use of the 'vacuum lifter', consisting of a rigid frame fitted with a series of vacuum holders. Vacuum lifting of precast elements permits earlier removal from mould or casting bed while at the same time eliminating bending stresses and surface damage (Fig. 8). The vacuum mat itself may be used for lifting and stacking small items such as paving slabs directly after treatment and before the processing vacuum is cut.

Application. In countries where steel is cheap and labour costs are high, the vacuum process should find wide application in works both large and small, in field and in factory.

The vacuum process is designed essentially to produce savings in materials and equipment, labour and time. Its principal economy is that it enables shuttering to be struck and re-used immediately after a surprisingly short period of processing, while at the same time resulting in a better concrete. Hence:

1. A small quantity of special gear at less capital outlay displaces a large part of the contractor's usual equipment (conventional shuttering, scaffolding, moulds for precast work, etc.).

2. There is a consequent reduction not only in the area required for production and storage but in transport and handling costs both for the processed product and the contractor's equipment.

3. For the average mix, a 25 per cent reduction in cement content actually increases the ultimate strength, thus design

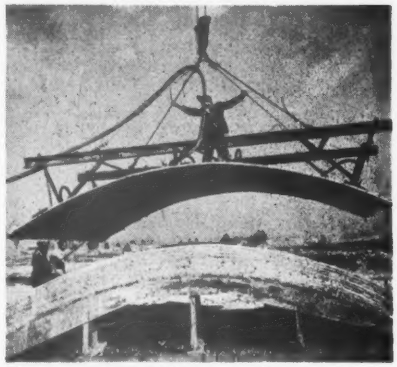


Fig. 8. Vacuum-lifting a roofing slab 1⅛ in. thick and 215 sq. ft. in area.

dimensions may be reduced or, alternatively, where specifications call for a certain compressive strength, the contractor can effect considerable savings in cement. If the steel frame must continue to be fireproofed in a concrete case, the same economies will apply.

4. The increased workability made possible by a high initial water/cement ratio overcomes the problem and cost of placing stiff, high-grade mixes where reinforcement is heavy. The designer's mind is freed from anxiety, and water control at the mixer ceases to be the seat of destiny of the whole concreting operation.

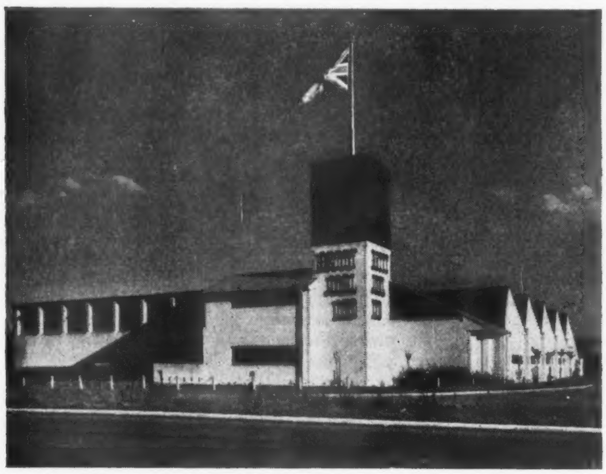
Field and laboratory tests have been carried out in France, Italy, Sweden, Germany and Russia each with the same general result—that all the desirable characteristics of concrete are improved through application of the vacuum process.

Acknowledgments. This article has been prepared, and figures 1, 2 and 3 drawn, from information made available through the Library of The Cement and Concrete Association, London, La Société du Vacuum Concrete, Paris, and Messrs. Millars' Machinery Company Limited, London, the Licencees for Great Britain and the Commonwealth.

The photographs have been kindly lent by La Société du Vacuum Concrete and Messrs. Millars' Machinery Company Limited.

St. Andrew's Presbyterian Church, Woking. Completed 1952. Architect: Graeme I. C. Highet [F]

Factories for Alford and Alder Ltd. and Rolls Razor Ltd., Hemel Hempstead New Town. Completed 1953. Architect: W. Leslie Jones [L]
[Photo: Architects' Journal



Furniture factory for Betty Joel Ltd. on the Kingston By-Pass. Completed 1935. Architect: H. S. Goodhart-Rendel [F]

R.I.B.A. Collection of Photographs of Architects' Work

WE ARE REPRODUCING some samples here from the Collection of Photographs which the Royal Institute started last year and of which full particulars were announced in the JOURNAL of September 1953. So far there has been a disappointing response and these samples are being illustrated to draw attention to the scheme.

The objects of the scheme are to provide reference material for the press, lecturers' and writers' illustrations, for all of which the Royal Institute receives a considerable demand; to provide material for R.I.B.A. exhibitions; to form a record of work done throughout the country, particularly work which is not normally illustrated in the architectural periodicals. Many of the photographs so far submitted have already been used for these purposes but many more are needed if the collection is to fulfil its purpose adequately.

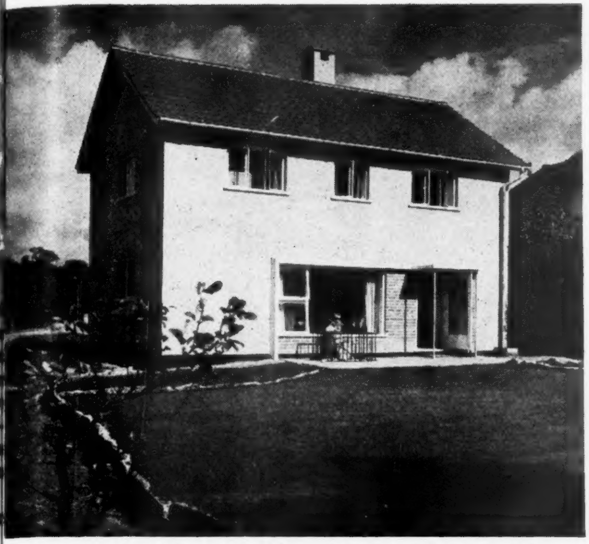
The following are the rules which members are asked to observe in submitting material:

1. All photographs must be addressed to the Secretary, R.I.B.A., 66 Portland Place, W.1, and packages should be marked in the top left-hand corner *Photograph Collection.*
2. Photographs should be unmounted 10 in. by 8 in. on glossy paper.
3. Not more than two separate jobs may be submitted per annum (i.e. between 1 January and 31 December).
4. Not more than three photographs or two photographs and one drawing of each job (drawings to be the same size as photographs to facilitate filing) to be submitted. Photographs should indicate as much as possible the nature and character of the job.
5. Up to 31 December 1954 architects may submit photographs of buildings completed any time since 1935 (but not earlier and not more than two jobs). After December 1954 no material should be submitted of buildings completed earlier than 1945. The decision to include work from 1935 onwards during the first year has been taken to allow examples of certain types of buildings to be included which have not been built since the war. Nevertheless, it is hoped that the bulk of material sent in will consist of post-war work.
6. On the back of *each* photograph the following particulars should be given: (1) Name and address of architect. (2) Nature and location of job. (3) Date of completion. (4) Name and address and reference number of photographer. (5) Name and address of copyright holder. (6) State if a reference to the job has appeared in the technical press with the name and date of the publication. (*N.B.* No detailed information is to be submitted on any drawing unless subsequently requested.)

A formal acknowledgment of the receipt of photographs will be sent, but the Royal Institute cannot enter into any correspondence in connection with the submitted photographs.

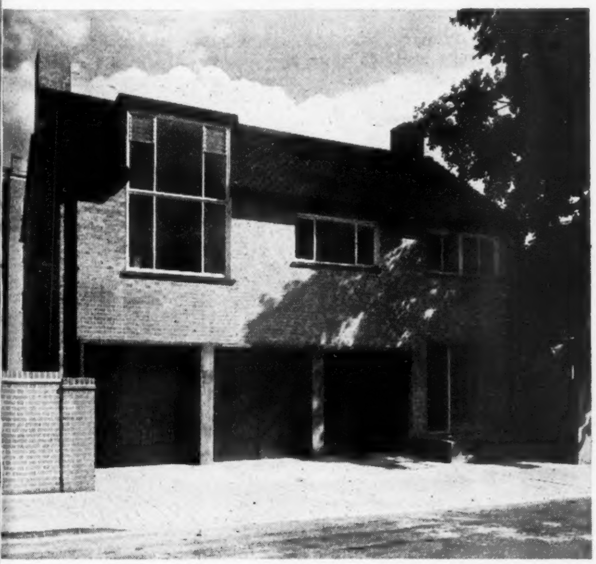
Photographs submitted will be displayed (without the name of the architect appearing) at meetings of the Public Relations Committee, where members will vote on the suitability of the photographs for inclusion in the collection. All photographs will, however, be retained for one year.

It is hoped that members will do their best to make this collection of real help in the task of publicising the work of architects. The Public Relations Committee cannot do this effectively without the ammunition which this collection can and should be. Exhortations to members of the public to employ architects are next to useless; they require to be shown the kind of thing that architects in general can provide and not merely a few selected examples of work by leading practitioners. Moreover, regionalism is important; examples are required from all parts of the country.



House at Petersham, Surrey. Architect: John Ratcliff, O.B.E. [A]

House at Malden, Surrey, designed to be extended. Completed 1948. Architects: Tayler and Green [FF]



Flats with garages and studio. Belsize Park, London. Completed 1953. Architect: Frank Scarlett [F]

Agricultural Research Building, Rowney Green, Worcs., for research into hydroponic culture. Completed 1952. Architect: F. Potter [F]

House at Chorley Wood, Herts. Completed June 1952. Architect: Alexander Gibson [F]
Photo: Architects' Journal

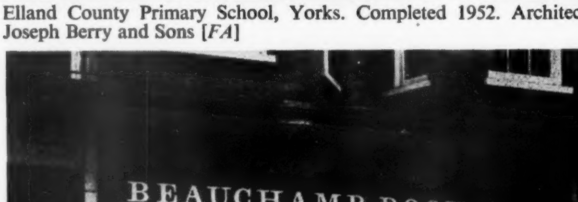
House in Cambridge. Completed 1951. Architect: G. M. Vickers [A]

Shop interior for Austin Reed Ltd., Victoria St., London. Completed 1953. Architect: N. C. Westwood of Westwood, Sons and Harrison [FF]

Library for the National Institute of Social and Economic Research. Completed 1952. Architect: John Diamond [A] *Photo: Design Research Unit*

Elland County Primary School, Yorks. Completed 1952. Architects: Joseph Berry and Sons [FA]

Factory for Nu-Way Heating Plants Ltd., Droitwich, Worcs. The dispatch loading bay. Completed 1951. Architect: F. Potter [F]



New shop front, Harrington Road, London, S.W.1. Completed 1951. Architect: Kenneth Bayes [F] *Photo: Design Research Unit*

Review of Construction and Materials

This section gives technical and general information. The following bodies deal with specialised branches of research and will willingly answer inquiries.
The Director, The Building Research Station, Garston, near Watford, Herts.
Telephone: Garston 2246.
The Officer-in-charge, The Building Research Station Scottish Laboratory, Thorntonhall, near Glasgow.
Telephone: Busby 1171.
The Director, The Forest Products Research Laboratory, Princes Risborough, Bucks.
Telephone: Princes Risborough 101.
The Director, The British Standards Institution, 2 *Park Street, London, W.*1.
Telephone: Mayfair 9000.
The Director, The Building Centre, 26 *Store Street, Tottenham Court Road, London, W.C.*1.
Telephone: Museum 5400 (10 *lines*).
The Director, The Scottish Building Centre, 425–7 *Sauchiehall Street, Glasgow, C.*2.
Telephone: Douglas 0372.

Prefabrication in Shipyard at Lowestoft. A shipyard for Messrs. Brooke Marine Ltd., Lowestoft, is under construction by Messrs. Dowsett Engineering Construction Ltd. (Midland area), and it is claimed that the main buildings are the first precast prestressed concrete factory-produced buildings of this size to be erected, certainly in this country if not in the world; the choice of this form of construction being influenced by the consideration that (*a*) the buildings would be free of maintenance, as the materials used would not be affected by atmospheric conditions, whereas deterioration of steel at this site would be abnormally quick; (*b*) normal decoration would be reduced to a minimum, as a permanent colour finish can be cast into the facing units; and (*c*) all fixings of units can be incorporated in the construction of the unit, provision being made for pressure grouting where bolts are used.

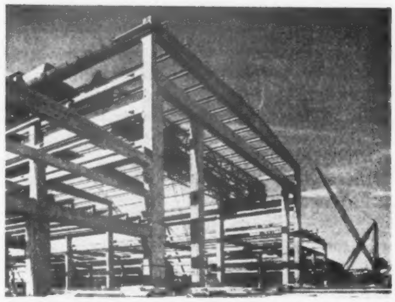
The main buildings are the prefabricating shop and the engineering shop, each being 360 ft. long by 150 ft. wide, with a central bay 75 ft. wide and two side bays 37 ft. 6 in. wide; the height of the central bays is 41 ft. 6 in. from floor to roof beams and 20 ft. in the side bays. Each central shop has to carry a 10-ton electric overhead travelling crane of 72 ft. span.

The main columns are of reinforced concrete suitably shaped to receive the prestressed concrete crane gantry bearers and having integral brackets to take the roof bearers over the annexes; in fact all members of the structure, except the columns, are prestressed. The columns weigh 16 tons each and are massive, but this is part of the basic design of using the strength of the columns to resist wind loading on the sides and vertical loading, including any eccentric effects that may arise from the cranes and floors; indeed, the weight of the concrete in all the units has been relied on to resist overturning effects from wind.

The main roof beams are 1 ft. 8 in. wide and 4 ft. at the centre, reducing to 1 ft. 9 in. at the ends; they weigh 15 tons each. To meet wind effects the lintel over the gable doors is a hollow prestressed beam 2 ft. 10 in. by 1 ft. 9 in. and rests on the two intermediate columns which frame the door opening, the end connections to the corner columns being designed to allow for a slight subsidence of the gable columns. The roofing is being carried out in asbestos cement troughing sheets laid to a very slight fall from the centre to each side, both over the main central space and the annexes, and to avoid any percolation of water at the laps the ends of the sheets have been upswept to form the equivalent of a drip of two or three inches' effective height. The valley gutters are in prestressed concrete. Side cladding is in asbestos cement sheeting and Perspex down to 9 ft. from ground level or to first floor where this occurs; prestressed concrete slabs being used up to that level to avoid damage.

The concrete units were manufactured by Messrs. Dow-Mac (Products) Ltd. at their works in Tallington, and Messrs. Dowsett point out that by simple modification in design the constructional system can be applied to large factories, hangars, exhibition halls and similar buildings, and that it lends itself to rapid erection on the site.

Making Older Houses Fit to Live In. The Coal Utilisation Council have issued a booklet in which they go more deeply into this subject than by merely endorsing the general opinion that it is a 'good idea'. The Council ask three pertinent questions: (1) What amenities do the people who live in these houses actually want? What scale of hot water supply, cooking facilities and room heating will match the way of life they are known to prefer? (2) How much extra, if anything, can they afford to pay for the amenities they want? (3) Are there any other special considerations arising



Prefabricating shop at Lowestoft, showing doorway lintel and columns

from their way of life and the kind of houses they live in that should affect the form these improvements take?

These are 'down-to-earth' questions, and the booklet answers them as follows:

Answer to Question 1. We know that the vast majority of these families need only simple cooking facilities for easily-prepared dishes; that they want more hot water than they now have, probably from a kettle, but they do not want an endless (and expensive) supply; that in general only one room is actually 'lived in' and has to be heated, and that this room is, in many cases, the kitchen.

Answer to Question 2. The running costs of new appliances installed in these substandard houses will be of vital importance to the tenants, though many are prepared to pay something extra. Cheapness is a major consideration.

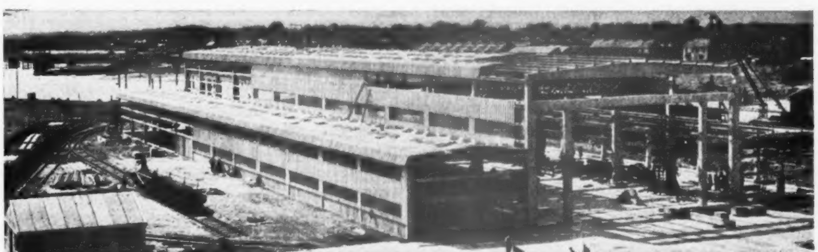
Answer to Question 3. Ninety-two per cent of these families prefer solid fuel for heating the main living-room, they like 'a bit of fire and a kettle on the hob'; and they will certainly have it, whether other provision is made for cooking and water heating or not. As the majority of these old houses are small there is simply not room for a number of new appliances.

The booklet then describes various suitable appliances.

The address of the Coal Utilisation Council is 3 Upper Belgrave Street, London, S.W.1.

Explosions in Domestic Flues. The following is extracted from the Technical Notes in the July 1954 JOURNAL OF THE FIRE PROTECTION ASSOCIATION.

'A number of cases of explosions in the flues of domestic solid fuel boilers, resulting in damage to the brickwork surrounding

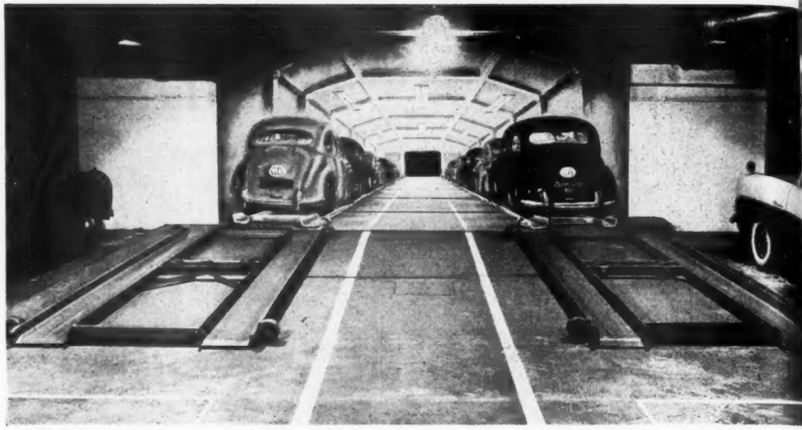


General view of prefabricating shop at Lowestoft, showing asbestos cement and Perspex sheeting

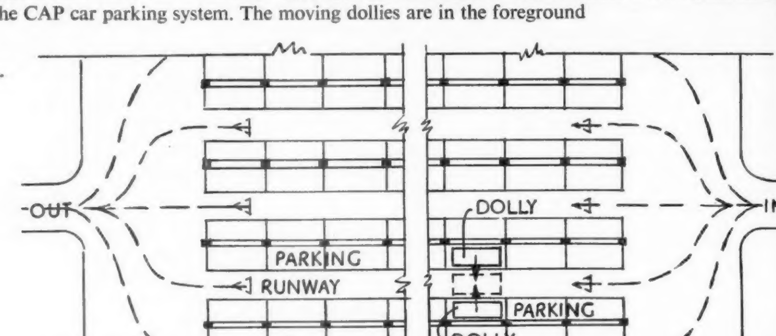
the flues, have been reported to this Association.

'These explosions, which fortunately are not common, are due to the ignition of an accumulation of flammable gases in the flue resulting from incomplete combustion of the fuel in the stove while the fire is burning slowly.

'Incomplete combustion may, of course, occur whenever the air supply to the boiler is restricted, but explosions in flues are not common because a combination of circumstances, which does not frequently arise, is required before conditions conducive to an explosion can exist. These conditions are believed to be: a fire that has been banked up for some time; a cold flue causing pockets of unburnt gas to form, a condition aggravated by bends in the flue; the right proportion of unburnt gas; and the admission of air to the flue upon stoking. At this stage a spark or flame may cause an explosion.'



The CAP car parking system. The moving dollies are in the foreground



The CAP car parking system. Diagram of a typical lay-out

A New Car Parking System. In speaking at the annual Press luncheon of the Automobile Association the Duke of Edinburgh referred to the vexed question of car parking, remarking that whether above or below ground mechanical methods are most important, particularly if it be remembered that for a given space 25 per cent more cars can be parked if mechanical methods are used.

The CAP parking system is a step, and a long one, in this direction. The available space or site is divided into parallel galleries normally 22 ft. wide. In the centre of each gallery is a corridor or runway 7 ft. wide, and on each side of the runway are bays in which are platforms, or dollies, moving on wheels with a central wheel having a flange running in a transverse slot. The dollies have two wide troughs to take the wheels of the cars, and move sideways by hydraulic (or electric) power.

When it is wished to park a car, the appropriate control switch is operated and the dolly in the chosen bay moves sideways into the runway; the car is driven on to the dolly which is then moved back into its 'home' bay, carrying the car with it. When the owner calls for his car the procedure is reversed and the car is driven off the dolly and along the runway to the exit. Traffic is thus one-way; all cars move in a straight line, there is no turning or manœuvring and therefore no risk of damage; each car remaining undisturbed on its dolly in its bay until wanted. Another point is that a car can be parked or unparked without moving any other car. The time taken for each operation is 10 seconds.

The normal lay-out is based on the fact that 80 per cent of cars are not longer than 16 ft., but of course sections of the lay-out can be given bays longer or wider to take large cars.

For comparison purposes the inventor, Mr. H. C. Trench, gives the following statistics: for 90-degree parking (one car alongside the next) the approximate space taken up by an average car is 232 sq. ft. with 184 cars to the acre; with 45-degree parking a car takes up 300 sq. ft. at 145 cars to the acre; in the CAP method an equivalent car takes up only 173 sq. ft. and 260 cars to the acre can be parked.

The CAP system of mechanical car parking is controlled by Messrs. CAP Parking Systems Ltd., 6 Bedford Row, London, W.C.2. Mr. Robert Cromie [*F*] is the consulting architect.

Building Bulletin 2A. The Ministry of Education have published this bulletin, which is the second edition of a supplement to Building Bulletin No. 2, and deals with new secondary schools. It is dated August 1954.

Building Bulletin No. 2 suggested principles of secondary school planning appropriate to the present economic situation, but made detailed recommendations which apply directly only to secondary modern schools of between ten and twenty forms. The new supplement 'considers how the same underlying principles of planning may be applied to other types and sizes of secondary school, and in certain respects restates their application to the more usual sizes of secondary modern school. In particular, the recommendations of Building Bulletin No. 2 are amended or restated where they conflict with the 1954 Building Regulations.'

The contents of the supplement include secondary modern schools, secondary grammar schools, secondary technical schools, bilateral secondary schools, comprehensive secondary schools, building by instalments and the control of cost. There are numerous tables and diagrams. The booklet can be obtained from H.M.S.O., price 3*s.* 6*d.* net.

Fibre Building Boards. The Fibre Building Board Development Organisation (Fidor) have issued a new edition of their book on fibre building boards; it has been extensively revised and now contains additional chapters, one on fire resistance and the other on factory-made buildings.

A 'tree' shows fibre building board branching into the three main classes of insulating board, wallboard, and hardboard, with their respective ramifications, and diagrams and technical details give information on the properties, applications and methods of fixing.

The book can be obtained from the Organisation, Melbourne House, Aldwych, London, W.C.2, price 5*s.* 6*d.*, including postage.

British Standards Recently Published

B.S. 144: 1954. **Coal Tar Creosote for the Preservation of Timber.** In this revised edition a single type of creosote has been specified, and terminology and methods of test have been brought up to date. Price 3*s.*

B.S. 913: 1954. **Pressure Creosoting of Timber.** In this revision the emphasis has been shifted from gross absorptions of creosote to net retentions. Price 2*s.* 6*d.*

The Presentation to Dudok

'e have received reports of the speeches by V. M. Dudok and of the Burgomaster of Hilversum at the ceremony on 5 August when book illustrating his work was presented Dudok to mark his seventieth birthday.

HE BURGOMASTER, Mr. J. J. G. Boot, resenting the book, said it contained escriptions and drawings of the impressive eries of works created by Dudok between 915 and 1954.

He was aware that today there was no eason to call a man old merely because he ad reached the age of 70, least of all Dudok whose present activities ranged rom Ankara to San Francisco. But by hat age service with national and local uthorities, to which Dudok had dedicated is strength and talents for so many ears, had ended; this might well be an ccasion to strike the balance of achievements.

The Committee of Honour had come to he conclusion that the presentation ought o be a public ceremony and he was glad to elcome so many distinguished visitors both rom the Netherlands and from overseas, specially His Excellency the Minister of Education, Arts and Sciences, Mr. Hulsker.

The title of the book was *Dudok*, no nore, no less. It was far from easy to attach definite label to Dudok's ideas on architecture or to classify him in some distinct chool. None of the 'isms' could boast Dudok as 'one of them'. His wide erudition had pondered and weighed every important artistic trend and he had been inspired by many great artists and artistic treasures.

What a time it had been, in which Dudok had lived! The world had changed far more than ever before. The population of Holland had grown from 4,250,000 to 10,550,000. The old policy of *laisser aller* had become impossible and there had arisen serious and urgent problems in the provision of housing, parks and recreation grounds and the preservation of nature reserves. Town and regional planning had become a necessity and there had been a hard fight, in which Dudok had played a leading part, to convince the strongly individualistic Dutchman (to whom the saying 'I, skipper next to God', was very real indeed) of the need for order, vision and planning.

Addressing Dudok, the Burgomaster said, 'We are here together in the town hall you built, in the council chamber you designed, in the town that for nearly 40 years profited by your skill, your love of beauty and your foresight.

'This is the reason why the Committee wished to do homage to you. In doing so we pay tribute to the talented architect and town builder who, supported by brilliant qualities of character and making high demands on himself and others, achieved many wonderful things.

'You are one of the great men who can afford not to be too accessible to the opinions of others; but however fierce an opposition you had to evoke by inevitably giving voice to your acute judgment, the respect for your personality remained unchanged. That could not be helped, because your personal charm never allowed professional differences to become personal matters of dispute.'

Accepting the book from the Burgomaster, Dudok said: 'Too much praise is bad for a man; it is as bad for the soul as too much wealth is bad for the body. I do not stand so firmly in my shoes as did Johannes Brahms, who was highly praised and miserably abused in his day, but who—if we believe his biographer—let both praise and abuse ooze down his feathers with dignity and strength of character, because he knew his own value. Alas! in my case it is not like that at all. Praise still makes me intensely happy and abuse makes me utterly miserable.

'In the past few weeks I have received an extraordinary amount of praise and I am grateful indeed for it, but I hope I have too much common sense to become conceited. Some of it oozes down my feathers, nevertheless, because deep in my heart I feel I do not deserve such a tribute as this. After all, I have done too little.'

Mentioning some of the projects which he had designed but which had not been realised, Dudok went on to say: 'Partly I blame those people who were my antagonists, but most of all I blame myself. A really great man creates the conditions of his own life to a far greater extent than I have ever done. Truly, I feel that I do not deserve this great tribute.'

Speaking in French and English to the representatives of French, British and American architectural bodies who were present, Dudok said how grateful he was for the appreciation and great friendship which had come to him from overseas. Referring to Mr. F. R. Yerbury [*Hon. A*] he said: 'My old friend Yerbury is one of the finest of architectural photographers and he introduced my work to Great Britain some 30 years ago. His success was great because, some years later, I got the thing which I have most esteemed in my lifetime, the Royal Gold Medal.'

The book of his works with which he had been presented, he said, was a wonderful achievement; many people thought that making books of architecture involved no more than taking a few snapshots and having them bound, but that was far from the truth and he held in great respect the amount of work which had gone into this one.

He continued: 'I have always said I didn't want a book; I didn't need one. I have always held that one should wait until the man to whom the book is to be dedicated is dead. More often than not it does not seem worth while any more after his death, and the enthusiasm subsides. But you did not wait, and I am thankful after all; it is a beautiful thing to possess. But I would like to say this: I do hope this book will not come to rest like a tombstone on my creative activities. This book must not be the end. I ask for your understanding of this one truth: the only real tribute an architect desires by the nature of his profession is to be given the opportunity to fulfil his task as a creative artist. I hope this opportunity will be given to me in the years to come. I know there are not many years left for a man of 70, but I still hope to create my masterpiece tomorrow, so that I may write the second volume of this book myself.'

Practice Notes

Edited by Charles Woodward [*A*]

MINISTRY OF HOUSING AND LOCAL GOVERNMENT. Housing Repairs and Rents Act, 1954. The Ministry have published a booklet explaining the provisions of the Housing Repairs and Rents Act 1954 which will come into operation on 30 August. The title of the booklet is *The New Act—Repairs and Rents.*

Another booklet published by the Ministry is entitled *Grants for Improvements and Conversions* and explains the amendments made to the Housing Act 1949 by the 1954 Housing Repairs Act. Both booklets are obtainable at H.M. Stationery Office, price 4*d.* each net.

Circular 53/54 dated 3 August addressed to local authorities in England and Wales points out their powers and duties under the Act in respect of certificates of disrepair. The certificate must be in the form prescribed by the Minister and must specify the defects in respect of which it is issued. The landlord can then see what repairs he should carry out in order to get the certificate revoked and then claim a repairs increase in rent from the tenant.

The Act will come into operation on 30 August.

The Circular is obtainable from H.M. Stationery Office, price 2*d.* net.

The Housing Repairs (Increase of Rent) Regulations 1954, S.1.1954, No. 1036, are obtainable at H.M. Stationery Office, price 9*d.* net. The Regulations contain all the forms necessary to be used for the purposes of the Act.

Circular 55/54, dated 28 August, issued to housing authorities in England and Wales, explains the provisions of this Act, and gives notes on the Sections. Appendix IV contains the provisions of the Act in respect of grants for improvements and conversions. The Circular is obtainable at H.M. Stationery Office, price 1*s.* net.

NEW LEGISLATION. Among the many Acts of Parliament which have just received the Royal Assent are two which to some extent concern members. The Law Reform (Enforcement of Contracts) Act 1954 amends section 4 of the Statute of Frauds 1677 and repeals section 4 of the Sale of Goods Act 1893.

The Act of 1677 required a contract in

writing or a note or memorandum in writing in cases where a person agreed to serve or perform services for another person for a period of a year or more. The amending Act of 1954 repeals this requirement and where an architect's services are retained for work which will last for a year or more it will not be necessary to produce evidence in writing if a verbal agreement has to be enforced. This provision will not affect a contract between a local authority and an architect, which must always be executed under seal, and in cases where a limited company is obliged by its articles of association to contract under seal a written contract will still be necessary. The Amendment will usually relate to the employment of an architect by a private client.

The effect of the repeal of section 4 of the Sale of Goods Act 1893 is to abolish the need for a memorandum in writing when the goods bought exceed £10 in value. This might have a bearing on Condition 22 of the R.I.B.A. Form of Contract, though verbal orders under that Condition are probably rare.

The Law Reform (Limitation of Action, etc.) Act 1954 puts public authorities in the same position as an ordinary person in respect of legal proceedings to be taken against them. The period is now six years from the date of the Act giving rise to legal proceedings, except in cases of personal injuries, where the period is three years.

NATIONAL JOINT COUNCIL FOR THE BUILDING INDUSTRY. Amendments to National Working Rules. Rule 3A (m). Labourers using in the course of their normal employment mechanically-driven compressed air or percussive drills, picks or spades, rammers, tampers or hammers . . . 1*d.* per hour extra payment.

Rule 3B. Continuous extra skill or responsibility. The amendments to this Rule concern timbermen, well-sinkers and scaffolders recognised as such, together with men employed in connection with mechanical plant. The list of this plant is too long to reproduce here and the extra payments vary from 1*d.* to 6*d.* per hour above a labourer's rate.

These amendments will take effect on and from 4 October 1954.

The amendments are issued from the offices of the Council, 11 Weymouth Street, London, W.1.

ROYAL INSTITUTION OF CHARTERED SURVEYORS. Scale of Charges. A new edition of the Schedule of Professional Charges has been published by the Institution and is obtainable at its offices, 12 Great George Street, London, S.W.1, price 1*s.* The new edition includes the R.I.B.A. Scale of Charges which came into effect on 1 June last, and also the revised scale of charges for quantity surveying services.

'Work omitted as a whole.' In the September issue of the Institution JOURNAL the Quantity Surveyors Committee explain the meaning of the words 'omitted as a whole' when applied to clause 4 of the Scale of Charges for Quantity Surveying Services in connection with flat dwellings for local authorities and clause 2 (*a*) of the Scale for services in connection with housing schemes. Members should refer to the Institution's JOURNAL for the detailed explanation.

CONTRACTS FOR BUILDING WORK IN SCOTLAND. The Royal Incorporation of Architects in Scotland and the Scottish National Building Trades Federation (Employers) have negotiated a form of contract for building work in Scotland which took effect as from 1 September. The Associations of Local Authorities in Scotland have approved the substitution of the new form of contract for the Scottish National Building Code dated 20 December 1915.

It is interesting to note that the contract provides for payment of interest to the contractor where the architect fails to certify any sum to which the contractor is entitled, or if the final adjustment of the account is not completed within six months after the work has been completed in the terms of the contract. The interest is the current bank overdraft rate or 5 per cent, whichever is the less.

LONDON COUNTY COUNCIL GENERAL POWERS ACT 1954. Height of Buildings. This Act has now received the Royal Assent and the clause relating to the height of buildings reads as follows:—

Part II, Section 5. The following subsection shall be substituted for subsection (1) of section 51 (Height of buildings limited) of the Act of 1930:—

(1) (*a*) A building (not being a church or chapel) shall not be erected or subsequently increased to a height exceeding one hundred feet without the consent of the Council;

(*b*) In measuring the height of a building for the purposes of this section no account shall be taken of any ornamental tower turret or other architectural feature or decoration (hereinafter in this subsection referred to as 'architectural feature') constructed only for ornamental purposes or for the purpose of accommodating stairs, lift installations or water storage tanks and not used for any other purpose if the architectural feature does not exceed ten feet in height and all such architectural features taken together do not exceed in area five per centum of the area of the roof of the building but subject as aforesaid the measurement of the said height shall be taken to the level of the highest part of the building;

(*c*) Nothing in this subsection shall prevent the rebuilding of any building existing on the twenty-fifth day of August eighteen hundred and ninety-four to the height at which it existed on that date.

OBSTRUCTION OF RIGHT TO LIGH
A case of some interest is reported in T ESTATES GAZETTE for 21 August, as it seem to show that if the light to a window is be obstructed so as to prevent the acquis tion of a right to light, the obstruction mu be complete.

It appears from the report that the plain tiff's window, the top of which was 7 f above the ground and about 2 ft. fro the boundary of the properties, had bee obstructed from 1922 to 1951 by a woode framework with metal sheeting some 7 7½ ft. high opposite the window. In 195 the defendant removed the obstruction an began to erect a wall along the boundar as the wall of a garage. The plainti objected when the wall had reached certain height and in 1953 the defendan put back the wood and metal obstruction

The Judge found that the obstructio put up in 1922 had darkened the plaintiff' room but it was not completely dark an the plaintiff had acquired a prescripti right to a limited amount of light, and tha the effect of the wall and the re-erecte obstruction was to reduce somewhat th limited light in the room to which th plaintiff was entitled. The amount of ligh was reduced so little that the plaintiff wa not entitled to found an action upon it Judgment was given for the defendant.

Book Reviews

Sir Christopher Wren, by *John Summerson* (Brief Lives *series*, No. 9.) 7¼ in. 160 pp incl. 3 pls. + 8 pls. text illus. Collins 1953. 8*s.* 6*d.*

To present a survey of the life and work o Wren in their 'Brief Lives' series the publishers have for author Mr. John Summerson, whose task has been accomplished with his customary lucidity within the limitations set by the format.

From a biography of this type, written as a study of Wren's total achievement and not primarily from an architectural standpoint a picture emerges of the powers of his mind in what appear at first sight to be widely differing fields. Underlying this seeming versatility remains his constant application to problems of form, whether of mathematics, anatomy or structure. Backed by an unfailing excellence in matters of technique, this provides a link between such various contributions to knowledge and ar as the rectification of the cycloid, the first scientific injection into a living body, a 'weather-clock', the City churches and St Paul's.

Wren's interest in geometry, solid and plane, logically progressed to the practice of architecture and without doubt proved an excellent basis for his exercises in enclosing space, although it would scarcely have indicated the fertility of invention which he was to display.

His activity was continual and prolonged and it is a sad condemnation of the intrigues and policies of the time that he was

t the age of eighty-six, when widely cknowledged as the doyen of architecture n England, dismissed from his position as urveyor of Works on a trumped-up charge f incompetence.

ELAINE C. DENBY [*A*]

he Kentish Stour, by *Robert H. Goodsall.* ½ in. xiv + 229 pp. incl. double pl. (plan) + pls. and pp. of illus. Cassell. 1953. 15*s.*

he river Stour cuts through East Kent iagonally from Ashford to Pegwell Bay, aking a large irregular loop near the arshes at Sandwich. Robert Goodsall [*F*] et off one day with his children and a map to explore the whole length of the Stour' nd, using the river as a connecting link, he describes the towns and villages and their history, doing his best to make clear the complex genealogies of old Kentish families.

His architectural interest is revealed in the text as well as by the photographs, which range from the typical Kentish tile-hung cottage style of Worten Mill to the stately Georgian house of Godmersham Park with its wonderful oak-beamed and raftered barn. Mills and stately houses provide in fact a large part of Mr. Goodsall's material; he describes with equal enthusiasm the process of making paper and the associations of Godmersham with Jane Austen.

This book can be recommended for careful reading or for 'dipping into'. It is competently produced with a good index.

M. W.

Timber Progress and Desk Book for 1953. *W. E. Bruce*, ed. [Articles by *R. F. A. Eckersley* and others.] 8½ in. 175 + 'notes' pp. incl. pp. of illus. text illus. Cleaver-Hume Press. 15*s.*

All users of timber should find this book useful. Its articles, some by authorities whose knowledge has not been available in print before, contain up-to-date facts about the nature and possibilities of new timbers, adhesives, structural techniques and other subjects, written, as far as possible, in non-technical language.

House Planning to Accommodate Furniture

he National Association of Retail Furishers have drawn the attention of the Royal nstitute to the difficulties experienced by heir members in moving furniture in and out f new houses and the problems of furnishing enerally. After a preliminary talk between epresentatives of the Association and the fficers of the R.I.B.A. Town and Country lanning and Housing Committee, the ormer submitted the following memorandum.

elivery of Furniture. Owing to the narrowess of entrances and the low height of oorways and the narrowness, steepness nd awkward turns on staircases, great ifficulty is experienced in getting even comaratively small pieces of furniture into ooms. Low headroom on stairs, coupled requently with turns, does not permit assage of wardrobes, which have to be ismantled. It is not always realised, for nstance, that a 3-ft. wardrobe is more ifficult to get into a house than a 4-ft. one ecause the latter can be divided into two. lder furniture presents further problems s it often cannot be taken to pieces. Paricular difficulty is experienced in delivering urniture to blocks of flats as the use of lifts s generally not permitted. The question of etting furniture easily into and out of flats hould be borne in mind when plans are eing prepared.

uggestions. If staircases cannot be made ith more ceiling space so as to obviate the bove-mentioned difficulties, then some uptairs window or windows should be so ade that they can easily be taken out to ermit the passage of furniture. Similarly, ifts in flats should be constructed to carry urniture.

taircases. In many houses staircases are oo steep and the treads too narrow, with he result that it is impossible to ascend or escend the stairs without kicking or ubbing against the stair riser, to the severe etriment of the stair carpet. Not only do tair winders increase the expense of laying arpet, but the carpet tends to wear more uickly when laid on bends.

uggestions. Stair treads should be wider nd staircases not so steep. Winders should here possible be avoided and replaced if ecessary by quarter- or half-space landings. Straight flights and half landings are preferable.

Fireplaces and Bay Windows. Owing to the prevailing use of fireplaces which protrude far into the room—particularly corner fireplaces—and the frequently awkward shape of bay and French windows, the occupier is often compelled to choose one of three courses: (*a*) to buy a carpet too small for the room, leaving a large surround; or (*b*) to buy a larger carpet and have it cut round the fireplace or bay window, which spoils the carpet and makes the usual practice of periodically turning the carpet very difficult; or (*c*) to buy a close-fitted carpet, which naturally increases the cost very considerably.

Suggestions. With regard to fireplaces, the important measurement is that between the curb and the opposite skirting. This should be just over rather than just under multiples of ½ yard to accommodate carpet squares, and the length of the room should bear a close relation to the popular standard sizes of carpets as they are given below. There are certain standard sizes of squares or rectangular carpets and standard widths of broadloom and body carpet used in close fitting. It would be helpful if architects could bear this in mind when determining the dimensions and shape of rooms, particularly as regards ratio of widths to lengths, and room features such as fireplaces.

Fitted Carpets. Owing to the growing popularity of fitted carpets, and as so many houses are built with composition floors, the fixing of carpets becomes a real problem.

Suggestions. A wooden fillet let into the floors round the walls and fireplaces when the floor is laid would considerably simplify the fitting of carpets by allowing for tacking The alternative multiple of 27 in., being the width of body carpet generally used where close-fitted carpets are likely to be required, should also be borne in mind.

Halls, Bathrooms and Kitchens. The floors of these rooms are generally covered with linoleum, the standard width of which is 6 ft., and it would be of great assistance if the dimensions of these rooms could be maintained in multiples of 6 ft., e.g. 9 ft., 12 ft., 15 ft., or less rather than slightly in excess of these multiples.

Curtains and Pelmets. Considerable difficulty is often experienced in fixing curtain fittings to a reinforced concrete lintel over some windows, which makes the plugging difficult, not to mention damage caused to walls and tools.

Suggestion. Small wooden fillets should be let into the lintel, which would do much to facilitate the erection and fitting of pelmets and curtain fittings.

Doors and Doormats. Outside doors should have wells fitted to take standard-size doormats up to 1¾ in. thick. Alternatively thresholds should be fitted under doors to allow the doors to pass over a mat.

Standard Sizes and Dimensions. More attention should be paid by architects to the standard sizes of carpets, mats, lino, etc., and to the dimensions of furniture now being manufactured. Standard widths, dimensions, etc., are:

Wardrobes. 3 ft. wide—generally cannot be divided. 4 ft. and 4 ft. 6 in. widths—generally can be divided into two.

Divans and Bedsteads. 3 ft. or 4 ft. 6 in. wide, 6 ft. 6 in. long.

Sideboards. 4 ft., 4 ft. 6 in. or 5 ft. long.

Dining Tables. 4 ft. 6 in. by 2 ft. 3 in., 5 ft. by 2 ft. 6 in., 3 ft. by 3 ft. (closed), 5 ft. by 3 ft. (open).

Upholstered three-piece Suites.—Chairs: 2 ft. 6 in. to 3 ft. wide, 3 ft. deep back to front. *Settees:* 4 ft. 6 in. to 6 ft. wide, 3 ft. deep back to front.

Carpets. Squares: 7 ft. 6 in. by 9 ft., 9 ft. by 10 ft. 6 in., 9 ft. by 12 ft., 10 ft. 6 in. by 12 ft., 10 ft. 6 in. by 13 ft. 6 in. *Broadloom:* 9 ft. is generally the most common width. *Body carpet:* Usual width of body carpet for making fitted carpets is 27 in. *Stair: Carpet:* 18 in., 22½ in., 27 in., 36 in. wide.

Door Mats. No. 1, 14 in. by 24 in.; No. 2, 16 in. by 27 in.; No. 3, 18 in. by 30 in.; No. 4, 20 in. by 33 in.; No. 5, 22 in. by 36 in. Increasing 2 in. in width and 3 in. in length for each size—largest, 48 in. by 30 in.

Linoleum. Width 6 ft.

Notes and Notices

NOTICES

R.I.B.A. Award for Distinction in Town Planning. The R.I.B.A. Award for Distinction in Town Planning is the only award in town and country planning bestowed by the R.I.B.A. It is by conferment only and is limited to Fellows, Associates and Licentiates of the R.I.B.A. Outstanding work in the design and layout, not of individual buildings, but of groups of buildings will be recognised. The award will be made for actual planning work and while not primarily intended for housing layouts, such layouts of groups of buildings would not be excluded.

Recommendations are submitted to the Council by a Standing Committee set up for the purpose. Personal applications by candidates will not be entertained; the name of a candidate must be submitted by three or more sponsors, themselves members of the R.I.B.A., who will be required to submit details of the candidate's professional qualifications and experience and evidence of the candidate's actual planning work. Nominations may be made twice annually, on 1 March and 1 November, and must be addressed to the Secretary, R.I.B.A., 66 Portland Place, London, W.1.

Members upon whom the Award has been conferred will be entitled to use the designation 'R.I.B.A. Award for Distinction in Town Planning' and it is advised that this should be used in full, or the initials 'Dist. T.P.' after the initials 'F.R.I.B.A.', 'A.R.I.B.A.', or 'L.R.I.B.A.', according to the class of membership to which they belong.

New Building Materials and Preparations. The attention of members is drawn to the fact that information in the records of the Building Research Station, Garston, Watford, Herts, is freely available to any member of the architectural profession, and architects would be well advised, when considering the use of new materials and preparations of which they have had no previous experience, to apply to the Director for any information he can impart regarding their properties and application.

Members and Professional Affixes. The Council's attention has been called more than once to the practice among some members of adding a string of letters of doubtful value to the affix indicating membership of the Royal Institute on their letter paper.

This is a matter in which the Council obviously cannot dictate to members, and must trust to their good sense. It should be obvious, however, that the affix of a chartered body of high standing is weakened in effect by the addition to it of a string of other mysterious designations some of which probably indicate no more than the payment of an annual subscription.

COMPETITIONS

Church and Church House at Liverpool. The Liverpool Diocesan Reorganisation Committee invites architects to submit designs in competition for a new Church House and Chapel on the site of St. Luke's Church, Berry Street, Liverpool.

Assessor: Sir Giles Gilbert Scott, O.M., R.A. (Past-President).
Premiums: £800, £400, £200.
Last day for submitting designs: 16 December 1954.

Conditions may be obtained on application to P. Straw, Secretary, Liverpool Diocesan Reorganisation Committee, Church House, 47 Moorfields, Liverpool, 2.
Deposit, £2 2*s*. 0*d*.

Dow Prize Competition. The Illuminating Engineering Society offers a prize which will be awarded to the winners of a competition intended to encourage collaboration between students of illuminating engineering or of those branches of engineering concerned with illumination, and students in other fields in which applied lighting plays an important part. While entries from individuals are not excluded, the competition is primarily intended for students (under the age of 26) working in collaboration. The competition will be set and judged by a panel of assessors appointed by the Society in co-operation with the R.I.B.A. and the Institution of Electrical Engineers.

Premium: £75 (and a certificate to each member of the winning team).

Certificates of commendation will be awarded to any other entries of outstanding merit.

Last day for submitting designs: 15 November 1954.

Forms of application and instructions as to the form which entries should take may be obtained from the Secretary of the Illuminating Engineering Society, 32 Victoria Street, London, S.W.1.

COMPETITION RESULT

All-India Medical Institute, New Delhi. Mr. H. J. Brown [*A*] and Mr. L. C. Moulin [*A*] in association with Mr. A. H. Antrum [*A*].

ALLIED SOCIETIES

Changes of Officers and Addresses

Devon and Cornwall Society of Architects, Exeter Branch. Chairman, Mr. Edward Narracott [*F*], 48 Torwood Street, Torquay.

Essex, Cambridge and Hertfordshire Society of Architects, Cambridge Chapter. Mr. Donald A. G. McLeod [*A*], Hon. Secretary, has changed his address to 83a Regent Street, Cambridge.

South-Eastern Society of Architects, Guildford District Chapter. Chairman, Mr. W. S. Mercer [*L*]. Joint Hon. Secretaries, Mr. Frederick T. Orman, T.D. [*F*], and Mr. H. C. S. Workman [*A*], both at 106 High Street, Guildford, Surrey.

West Yorkshire Society of Architects. Joint Hon. Secretary with Mr. W. H. King [*F*], Mr. Ronald S. Shapley [*F*], at 11a Cavendish Road, Leeds 1 (Leeds 2-6250). *Huddersfield Branch:* Chairman, Mr. S. M. Richmond, A.M.T.P.I. [*F*].

The Ontario Association of Architects announces the removal of its offices to 50 Park Road, Toronto 5, Ontario.

GENERAL NOTES

R.I.B.A. Golfing Society. The annual match between the R.I.B.A. Golfing Society and the Royal Institution of Chartered Surveyors G.S. was played on Wednesday 21 July, again at New Zealand Golf Club, West Byfleet.

Fortunately the weather was excellent which, coupled with a most exciting match, resulted in a most enjoyable day's golf.

In the morning the Surveyors led in the singles by 6½ matches to 3½, but in the afternoon foursomes the Architects improved in partn ship, winning four of the five foursomes a halving the other. Thus the result was a w for the Architects on the day by 8 matches to

R.I.B.A. Cricket Club. *R.I.B.A. v. R.I.C. Hinchley Wood 18 August.*

Result

R.I.C.S.
M. W. Pickersgill, b Smyth
M. Fletcher, c Francis, b Case
A. Goater, b Francis
J. Porter, c Norton, b Francis
W. T. Smith, c Francis, b Fyson
R. Mash, stumped Leslie, b Fyson
J. C. Hawkes, c and b Francis
P. Penny, not out
L. F. Walters, stumped Leslie, b Fyson
D. G. Gray, not out
G. A. I. Williams, did not bat.
Extras

Total (for 8 Dec.)

Fyson 3 for 19; Francis 3 for 55; Case 1 for 2 Smyth 1 for 30.

R.I.B.A.
J. Kennedy Hawkes, b Walters
A. Douglas, b Mash
J. G. Batty, b Gray
B. S. Smyth, b Gray
G. Fyson, c Walters, b Gray
R. R. Fairbairn, c Williams, b Walters
C. A. R. Norton, b Walters
I. Leslie, not out
R. Case, not out
H. E. S. Francis, did not bat
G. R. Linfield, did not bat.
Extras

Total (7 wkts.)

Walters 3 for 39; Gray 3 for 44; Mash 1 for 3

R.I.B.A. v. C.C.C., Wimbledon, 1 September.

Result

R.I.B.A.
Marlow, b Sears
Kennedy Hawkes, b Sears
Robinson, c Sears, b Davies
Smyth, st Forsyth, b Davies
Fyson, lbw Davies
Douglas, run out
Norton, b Davies
Batty, c Sears, b Hill
Cooper, b Hill
Case, not out
Baverstock, b Hill
Extras

Davies 4 for 55; Hill 3 for 28, Sears 2 for 59.

C.C.C.
Brown, not out
Micklethwaite, lbw Smyth
Glendinning, b Norton
Davies, not out
Extras

Total (2 wkts.)

Smyth 1 for 31; Norton 1 for 53.

A.A. Evening Classes in Design. The Council the Architectural Association again wish offer facilities for evening classes in design architectural students who have passed th R.I.B.A. Intermediate Examination, and wh

are not attending at any school of architecture. The classes are not intended as a preparation for the R.I.B.A. Finals, but are to provide opportunities for discussion and criticism of students' work. The course will be staffed on an honorary basis. No charge will be made for tuition, but students will be required to pay a termly Registration fee of ten shillings and sixpence.

All students who might be interested are asked to write to the Principal's Administrative Assistant, 34/36, Bedford Square, London, W.C.1.

Obituaries

Richard Bertram Ling [*F*] died on 9 May, aged 70.

Mr. Ling was born at Addlestone in Surrey. His mother was a descendant of Sir Thomas Bodley, founder of the Bodleian Library, and his father was descended from immigrant Huguenot stained glass craftsmen of the seventeenth century. He was early left fatherless and made his way by means of scholarships. He was elected Associate in 1912 and Fellow in 1932.

War service in the first world war in the R.A.M.C., where he earned mentions in despatches for work in organising and directing hospital trains, took him to Italy, where he met and married a professor of languages at Genoa University. After the war he worked for the L.C.C. as architect and surveyor, becoming District Surveyor first at Woolwich and then at Camberwell. During this period he designed private houses and estate housing. On the outbreak of war in 1939 he organised and commanded the Rescue and Demolition section of Camberwell A.R.P. service. At the end of the war he was for a short time in private practice at Lindfield in Sussex, then entered the service of the War Damage Commission, specialising in the restoration of London churches. In 1947 he was appointed Central Office of Information lecturer on Town Planning, National Parks and New Towns.

Mr. Ling became a Freeman in the Worshipful Company of Gardeners shortly before the last war, and in 1953 was Master. He had considerable knowledge of the practical aspects of gardening and farming, and had a farm in Sussex. He was a past member of the R.I.B.A. Science Standing Committee.

Mr. Ling's widow writes of her late husband: 'For all his knowledge and understanding he was self-effacingly modest. Towards others gentle and unselfish, in himself he was very honest and conscientious; he worked unceasingly the whole of his life and put all of himself into whatever he did. Strongly dissatisfied with any falling short of perfection in his own work, he was always constructively appreciative of the efforts of others and respected their ideas, though nothing would move him to alter his own tested standards and ideals. As a true artist he saw beauty in all places and things. And his whole conception of life was that the same qualities of greatness and goodness can be found in people from all walks, that the actions and thoughts for good of all men, of whatever creed, are united in God. And he loved the mighty and the obscure with an equal fatherly warmth.'

R. P. Kennedy [*L*] died on 7 October 1953, aged 81.

Mr. Kennedy was for many years architect and surveyor to the Portman Estate, London, with whom in fact he spent the whole of his working life, having served his articles with a former architect to the Estate, Mr. F. W. Hunt [*F*]. Mr. Kennedy retired in 1940.

During the time that he was the Estate's architect and surveyor many large redevelopment and improvement schemes were initiated by him, and though these schemes were carried out by the developers' own architects the layouts and designs were frequently influenced by his decisions.

In private practice Mr. Kennedy carried out various domestic and ecclesiastical works, largely in collaboration with other architects. He had a keen interest in and extensive knowledge of the Tudor and early Renaissance periods of architecture, which influenced much of his own architectural work.

Gordon MacLeod Pitts [*F*], past President of the Royal Architectural Institute of Canada, died on 1 March 1954, aged 68.

He was born in Fredericton, New Brunswick, and attended McGill University, where he received the degrees of Bachelor of Science (with honours in Structural Engineering), Master of Science and Bachelor of Architecture. In 1919 he joined the firm of Edward & W. S. Maxwell, and became a partner in 1923, the firm then becoming Maxwell and Pitts. He was connected with a number of the larger construction works in Canada, including the Parliament Buildings, Ottawa (in his early days as assistant to John A. Pearson [*F*]); the Chateau Frontenac, Quebec; the Dominion Express Building, Montreal; national bridge works and Connaught Park development.

Mr. Pitts was a Governor of McGill University and Chairman of its Site Planning Committee, a Councillor of the City of Montreal as well as a member of the city's Town Planning Commission and Chairman of its Special Bridge Committee. He had represented the Royal Architectural Institute of Canada on the Council.

He was the author of *Transportation in Canada, Planning the Canada of Tomorrow* and other brochures on post-war planning, housing, etc.

Walter Thomas Armstrong [*Retd. A*] died on 18 August, aged 78.

Mr. Armstrong retired in 1941 after 39 years as Chief Architectural Assistant in the City Engineer's Department, Lancaster. Works which were carried out during his period of office include housing estates, Greaves school and Dallas Road school, a scheme for the widening of Cheapside, and the city's public library.

Mr. Armstrong was one of the original members of the National Association of Local Government Officers and was President of the Lancaster branch in 1934. He was a keen oarsman and golfer, twice captaining the John O' Gaunt rowing club and invariably accompanying the club's crews abroad to compete in foreign regattas.

Ernest Edmund Morgan, O.B.E., M.C. [*F*], past President of the South Wales Institute of Architects (1943–5), died on 11 August, aged 72. Mr. Morgan was for 35 years, until his retirement in 1946, Borough Architect of Swansea.

He served his articles with the late Mr. Glendinning Moxham and in 1910 went as a student to the British School in Rome. In 1912 he won the competition for the design of Swansea's police and fire station and became Swansea's first borough architect in the following year. Between the two world wars the Corporation erected over five thousand houses, and other works for which Mr. Morgan was responsible include Cefn Coed and Hill House hospitals, the early University College adaptations and buildings, and a number of elementary and secondary schools. He collaborated closely with Sir Percy Thomas, O.B.E. [*F*], architect of the city's Guildhall. He was well known in South Wales as a water colourist and for his lino-blocks, and frequently exhibited. He was a prominent Freemason and a Past Master of the Dr. James Griffiths Hall Lodge.

Mr. L. R. Gower [*F*] writes: 'Mr. Morgan was a gentleman of great personal charm and there is no doubt he will be greatly missed.'

Guy Church [*F*] died on 13 July, aged 74.

Mr. Church was articled to Professor Beresford Pite and practised in London from about 1912, with an interruption during the first world war in which he was engaged on government work. Mr. Church was responsible for two housing schemes at Bognor Regis and a number of private houses. He was architectural editor to *Ideal Home* and the author of *What About a House Again*, published by the Rockliff Publishing Corporation Ltd., after the second world war.

Reginald Neville Jackson [*A*], past President of the Natal Provincial Institute of Architects. The Institute has just received notification of the death of Mr. Jackson on 19 November 1953 at the age of 65.

He studied at the Architectural Association School of Architecture in London and served his articles with Sir John Burnet, but practised from 1926 onwards in Durban, Natal. There, in partnership with the late F. J. Ing [*F*] he founded the firm now known as Ing, Jackson & Short, which is being carried on by Mr. Jackson's son, Mr. M. A. Jackson [Student], and Mr. P. M. Short.

Mr. Jackson designed a number of buildings in Durban, including the Lion Match and the Shell Company buildings, also the war memorial at East London and, in conjunction with Mr. I. Park Ross, Natal Technical College Clubhouse, which won a bronze medal.

Fred Vaux [*F*] died on 18 July, aged 66. Mr. Vaux was a Housing Medal winner this year for houses at the Model Farm, Crown Grove, Yorkshire (Norton U.D.C.).

Mr. Vaux was born in Doncaster and served his articles with Pennington & Garside, Pontefract. He served for some considerable time in the Public Works Department, Accra, on the Gold Coast, and from there joined the West African Rifles in 1914. After the war—in which he was wounded—he opened a practice in Bridlington and continued in it, except for the period of the second world war, until his death. In the recent war he served with the R.E. at Catterick.

Mr. Vaux's biggest interest was in domestic architecture, and he designed housing estates for Driffield, Richmond, Norton and Filey local councils.

Members' Column

This column is reserved for notices of changes of address, partnership and partnerships vacant or wanted, practices for sale or wanted, office accommodation, and personal notices other than of posts wanted as salaried assistants for which the Institute's Employment Register is maintained.

APPOINTMENTS

Mr. T. S. Clerk [*A*] has been appointed Chief Architect and Town Planner of the TEMA Development Corporation and will be pleased to receive trade catalogues, etc., at the TEMA

Development Corporation, Private Post Bag, Accra, Gold Coast.

Mr. W. H. Cook [*A*] has left the employment of Messrs. Tripe and Wakeham, London, W.1, and taken up an appointment as Senior Assistant Architect to East African Railways and Harbours, P.O. Box 79, Nairobi, Kenya, where he will be pleased to receive trade catalogues.

Mr. Alan Fitch [*A*] has taken up an appointment as Architect, Public Works Department, Hong Kong. All correspondence should be sent to him c/o P.W.D., Hong Kong.

Mr. H. A. Fraser Spooner [*L*] has been appointed Chief Architect to the Southdown Motor Services Ltd., Steine Street, Brighton, and will be pleased to receive trade catalogues, etc.

PRACTICES AND PARTNERSHIPS

The Architects' Co-Partnership, of 44 Charlotte Street, London, W.1, have opened a branch office in Nigeria, at 1 Regis Aine Street, c/o P.O. Box 870, Lagos. **Mr. W. J. G. Godwin,** A.A.Dipl. [*A*], has become the resident partner since March 1954. Mr. Godwin and his wife, Jill Hopwood, A.A.Dipl. [*A*], will be pleased to receive trade catalogues.

Mr. W. T. Bebb, Dip. Arch. [*A*], has relinquished his appointment with Chepstow U.D.C. and has begun private practice at Manor House, Bank Square, Chepstow, Mon., where he will be pleased to receive trade catalogues, etc.

Mr. Edward J. W. Curtis, Dip. Arch. [*A*], has begun private practice at 87A Hornsey Lane, Highgate, N.6 (MOU 8634), where he will be pleased to receive trade catalogues, etc.

Louis de Soissons, R.A., and Partners announce that as from 6 August the name of the firm has been changed to **Louis de Soissons, Peacock, Hodges and Robertson.**

Mr. Alexander Martel [*A*] has resigned his position as Chief Architect with Rivero-Rodriguez Ings, S.A., while remaining architectural consultant to the company, and has opened a practice under the style of **Oficina de Arquitectura Alexander Martel** at 4 Edificio Riv-Rod, Calle Maria Teresa Toro, Urb. Las Acacias, Caracas, Venezuela.

Messrs. Smith and Wilson [*F*/*A*] have taken into partnership Mr. Stanley Hall Cox [*A*] as from the 1 July and the name of the firm will in future be **Smith, Wilson and Cox,** at 103 Bute Street, Cardiff.

Messrs. J. Stuart Syme [*F*] and **Cecil Leckenby** [*F*] have taken into partnership **Mr. D. A. Leckenby,** Dip. Arch [*A*]. The firm will continue to practise under the style of Brierley, Syme and Leckenby.

Mr. Marcel Sammut [*A*] is practising at 7 Amir Ibrahim, Gezira, Cairo, where he will be pleased to receive trade catalogues, etc.

CHANGES OF ADDRESS

Mr. Thomas J. Austin [*A*] has changed his address to 13A North Parade, Horsham, Sussex (Horsham 1868).

Mr. R. A. Boxall [*A*] of 161 London Road, Chelmsford (Chelmsford 3912), has opened new offices at 81 Moulsham Street, Chelmsford (Chelmsford 51212). In addition, a new branch office has been opened at 7 Market Place, Saffron Walden, in association with **Mr. Ronald H. Mobbs** [*A*].

Messrs. John Dudding and Partners (J. W. M. Dudding [*F*], with associates John Middleton, Dip. Arch. [*A*] and A. B. Grove, Dip.T.P., A.M.T.P.I.) have removed to 30 Clarendon Street, Nottingham. Telephone as before—Nottm. 44196.

Messrs. Gotch, Saunders and Surridge, Bank Chambers, Kettering, have opened a branch office at 38 High Street, Corby, Northamptonshire (Corby 3253).

Mr. Walter Greaves [*A*] has removed his Fitzroy Square office to 71 Blandford Street, W.1. (WELbeck 4713), where he will be pleased to receive trade catalogues, etc.

Lionel E. Gregory [*A*] has changed his address to 9 Parkstone Road, Poole, Dorset (Poole 1720–1).

Mr. Ernest K. Heyman [*A*], formerly of Leeds, has removed to 40 Worcester Crescent, Mill Hill, London, N.W.7 (MILl Hill 4500).

Mr. Charles F. Iden [*A*] has changed his address to 34 Featherbed Lane, Addington, Croydon, Surrey.

Mr. C. W. Lowe [*A*] has changed his address to 'White Poplars,' Lubbock Road, Chislehurst, Kent (Imperial 3957).

Mr. J. H. Milnes [*A*] has changed his address to Flat No. 12, Forest Court, Snaresbrook Road, Snaresbrook, E.11.

Mr. H. R. Parkin [*A*] has removed to new offices at 8 St. Paul's Road, Newton Abbot, S. Devon (Newton Abbot 1378). He has also opened a branch office at 8 Brownston Street, Modbury, S. Devon (Modbury 278).

Mr. Ian M. Parsons [*A*] has joined the staff of the Borough Architect, Southampton, and his permanent address is now 198 Aldermoor Road, Southampton.

The address of **Mr. Alan S. Raimes** [*A*] is now c/o Messrs. W. H. Warkins and Partners [*FF*], 14 St. Vincent Street, Port-of-Spain, Trinidad, British West Indies.

The address of **Mr. G. W. T. Rankine,** A.M.T.P.I. [*A*], is now 37 Royal Crescent, London, W.11.

The address of **Mr. B. C. Sherren** [*F*] is now 'The Kittoch', 6 Mount Park, Carshalton, Surrey (Wallington 5258).

Mr. Hugh V. Sprince, A.A.Dipl., A.M.T.P.I. [*A*], has moved his office to 7 Red Lion Square, London, W.C.1 (CHAncery 2033).

The address of **Mr. R. C. Stones** [*A*] is now 300 Burton Road, West Didsbury, Manchester 20.

From 24 September the address of **Mr. A. K. Sutton** [*A*] will be c/o Central Mortgage and Housing Corporation, Montreal Road, Ottawa, Canada.

Mr. Sidney Toy [*F*] has changed his office address to 14 North Audley Street, Grosvenor Square, London, W.1 (MAYfair 6036).

The address of **Mr. R. M. Wackerbarth** [*A*] is now 43 Crescent Road, Shepperton, Middlesex.

Mr. Henry Wellesley Wesley [*A*], on leaving Argentina for the U.S.A., has resigned from the appointment of Local Architect in Buenos Aires to the Ministry of Works, and the firm of **W. D. Campbell and H. W. Wesley** in that city has been dissolved by mutual consent. Mr. Wesley's future address will be c/o R. J. Burke, 303 Heliotrope Avenue, Corona del Mar, California, U.S.A.

PRACTICES AND PARTNERSHIPS WANTED AND AVAILABLE

Associate (39) returning to U.K. from abroad in December wishes partnership or post leading thereto in south or south-east England. Varied experience at home and abroad. Some capital available. Box No. 89, c/o Secretary, R.I.B.A.

Member, 25 years' experience as principal, commercial, industrial and other work, seeks partnership in established practice in London or southern counties. Some capital available. Box No. 92, c/o Secretary R.I.B.A.

Fellow with wide and responsible experience in England and abroad seeks partnership or position leading thereto. Some capital available. Box 97, c/o Secretary R.I.B.A.

Associate (Dip. Arch.) 35, seeks partnership or position leading thereto. Some capital available. Wide practical experience. Box 98, c/o Secretary R.I.B.A.

A firm of architects in London with large general practice would like to contact a member with a view to a junior partnership. Applicant should be about 30 years of age, preferably trained at the A.A. or Bartlett schools, and have first-class ability and good experience. The matter of any capital payment need not arise. Box 90, c/o Secretary, R.I.B.A.

Fellow with old-established practice 20 miles from London desires to meet an Associate with a view to partnership. Box 91, c/o Secretary, R.I.B.A.

WANTED AND FOR SALE

For sale: pre-war Double Elephant mahogany T-square, one half-Imperial drawing board, one half-Imperial ('Classic') T-square, second-hand copy *Surveying and Levelling Instruments,* by W. F. Stanley. Box 93, c/o Secretary, R.I.B.A.

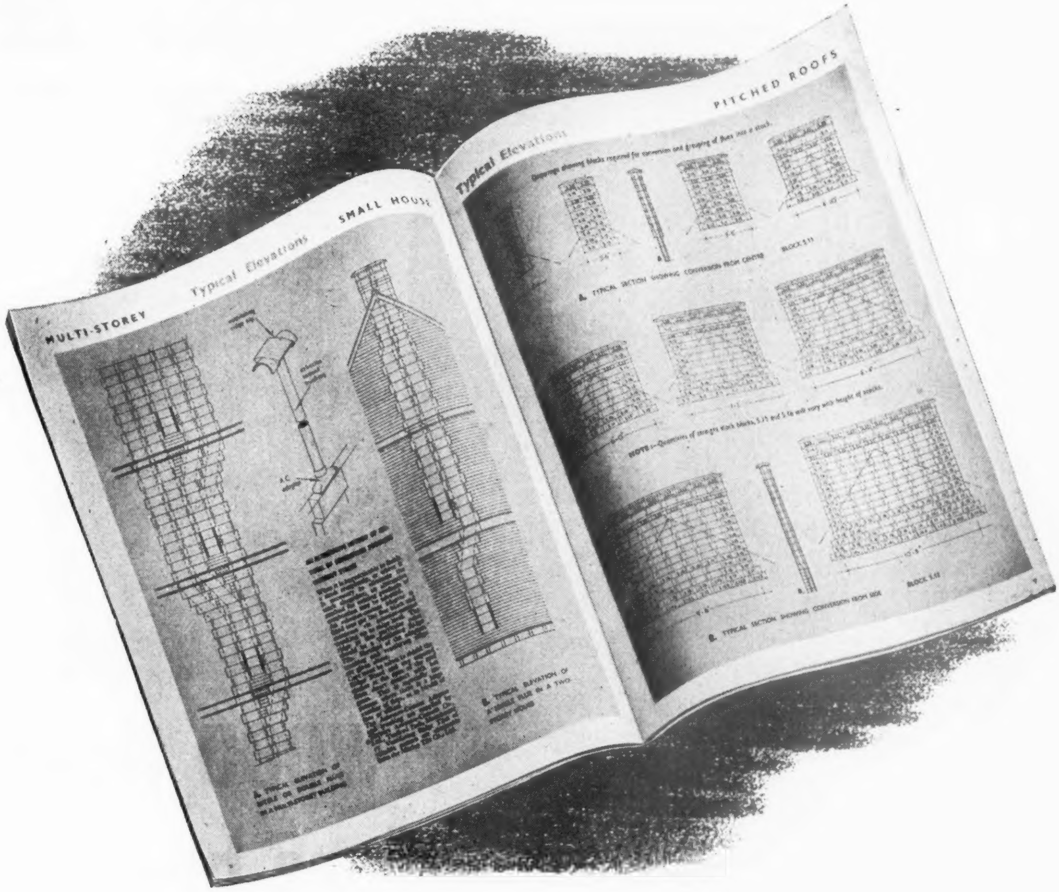
Wanted: COUNTRY LIFE magazine, 4 and 11 August 1928. Box 94, c/o Secretary, R.I.B.A.

ACCOMMODATION

Fellow with offices in W.C. district of London has office accommodation to offer a younger architect in return for low rental plus partial service of administrative nature. Box 95, c/o Secretary, R.I.B.A.

Architects with expanding practice in London and home counties require the use of one office and telephone and the share of typist's services. Area preferred, city or west central districts. Box 96, c/o Secretary R.I.B.A.

The Royal Institute of British Architects, as a body, is not responsible for statements made or opinions expressed in the JOURNAL.



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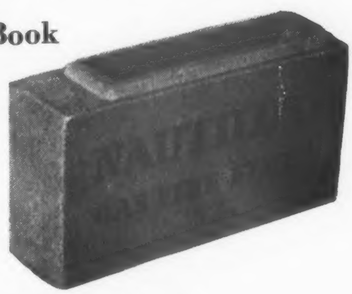

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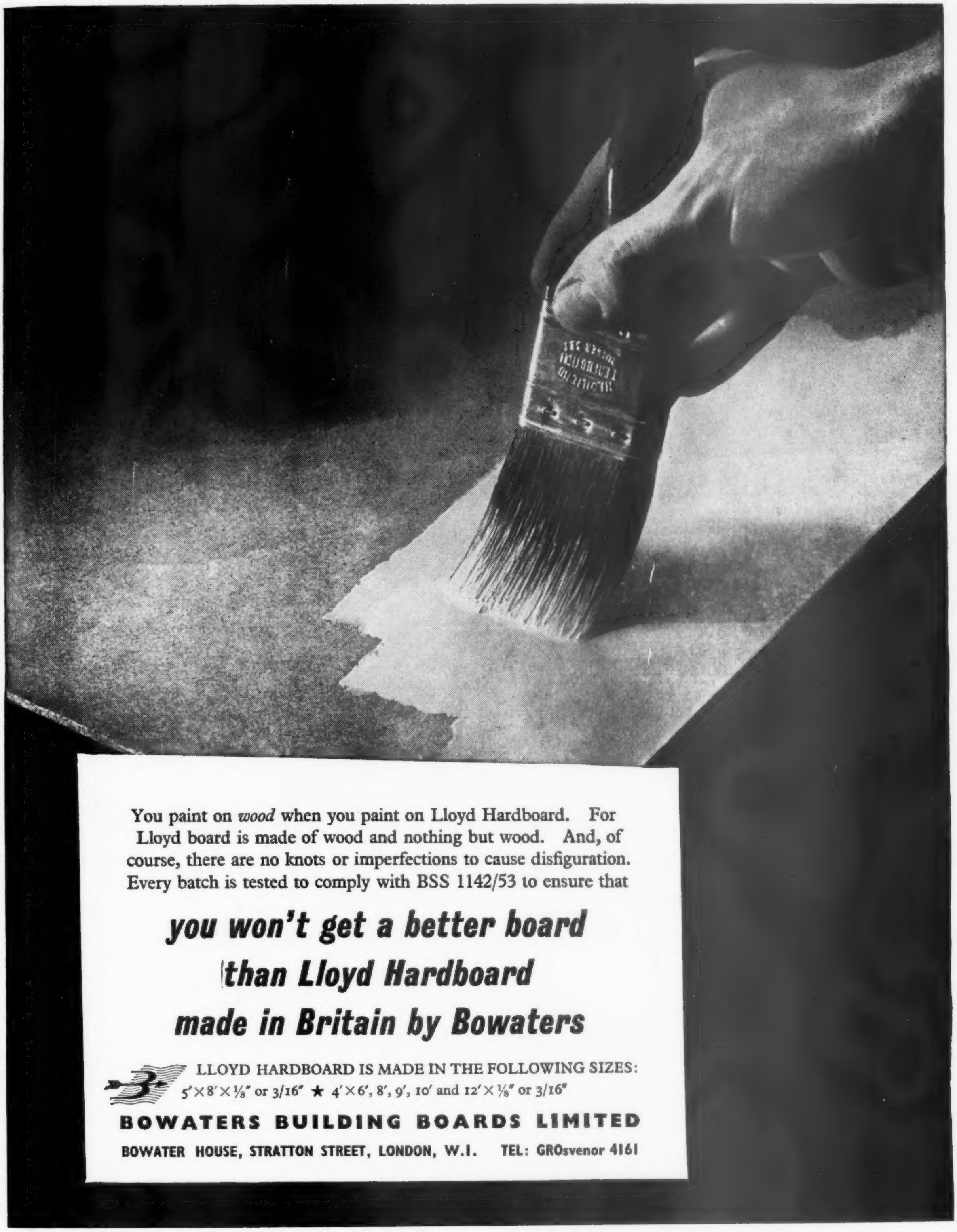
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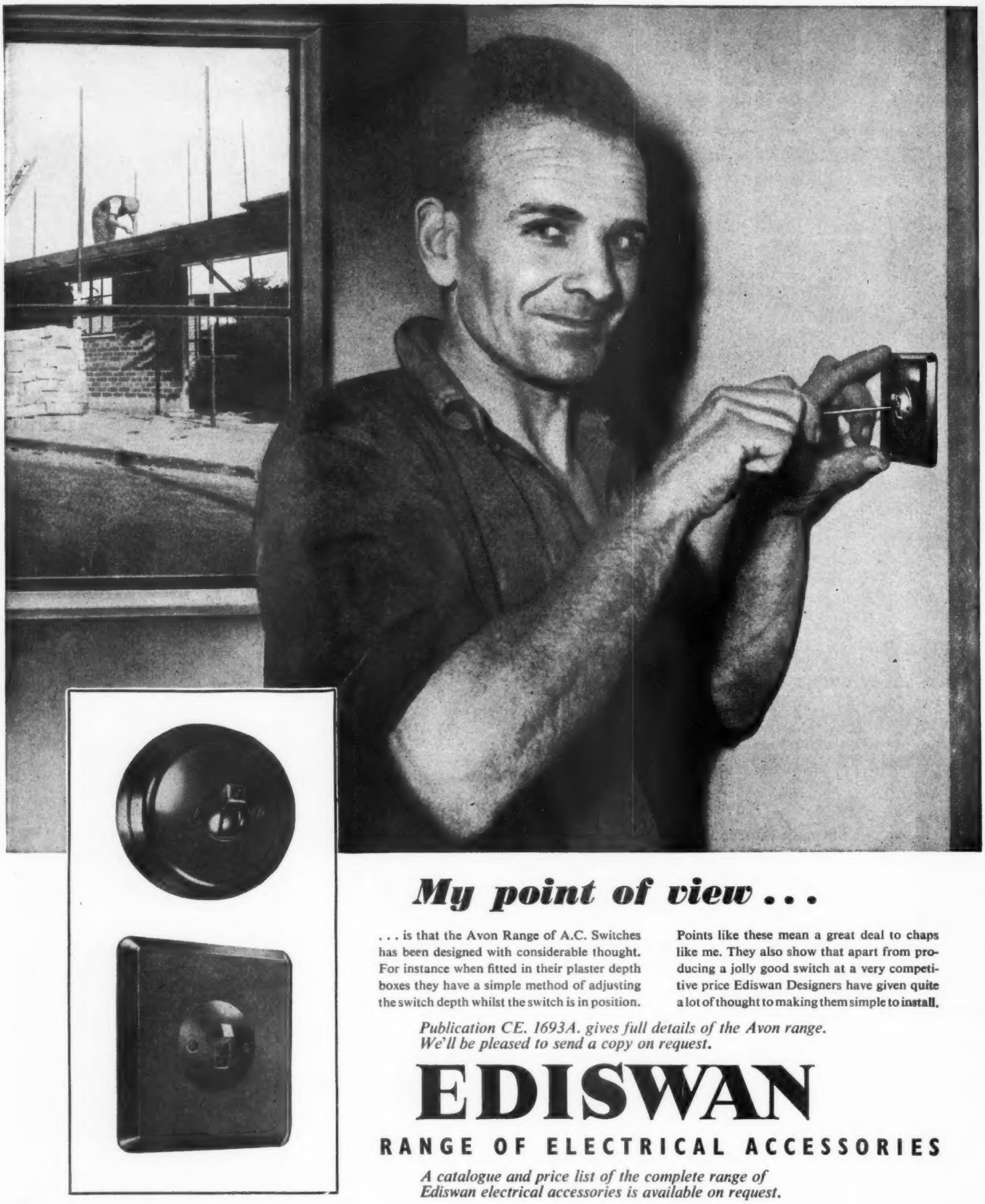

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. . . is that the Avon Range of A.C. Switches has been designed with considerable thought. For instance when fitted in their plaster depth boxes they have a simple method of adjusting the switch depth whilst the switch is in position.

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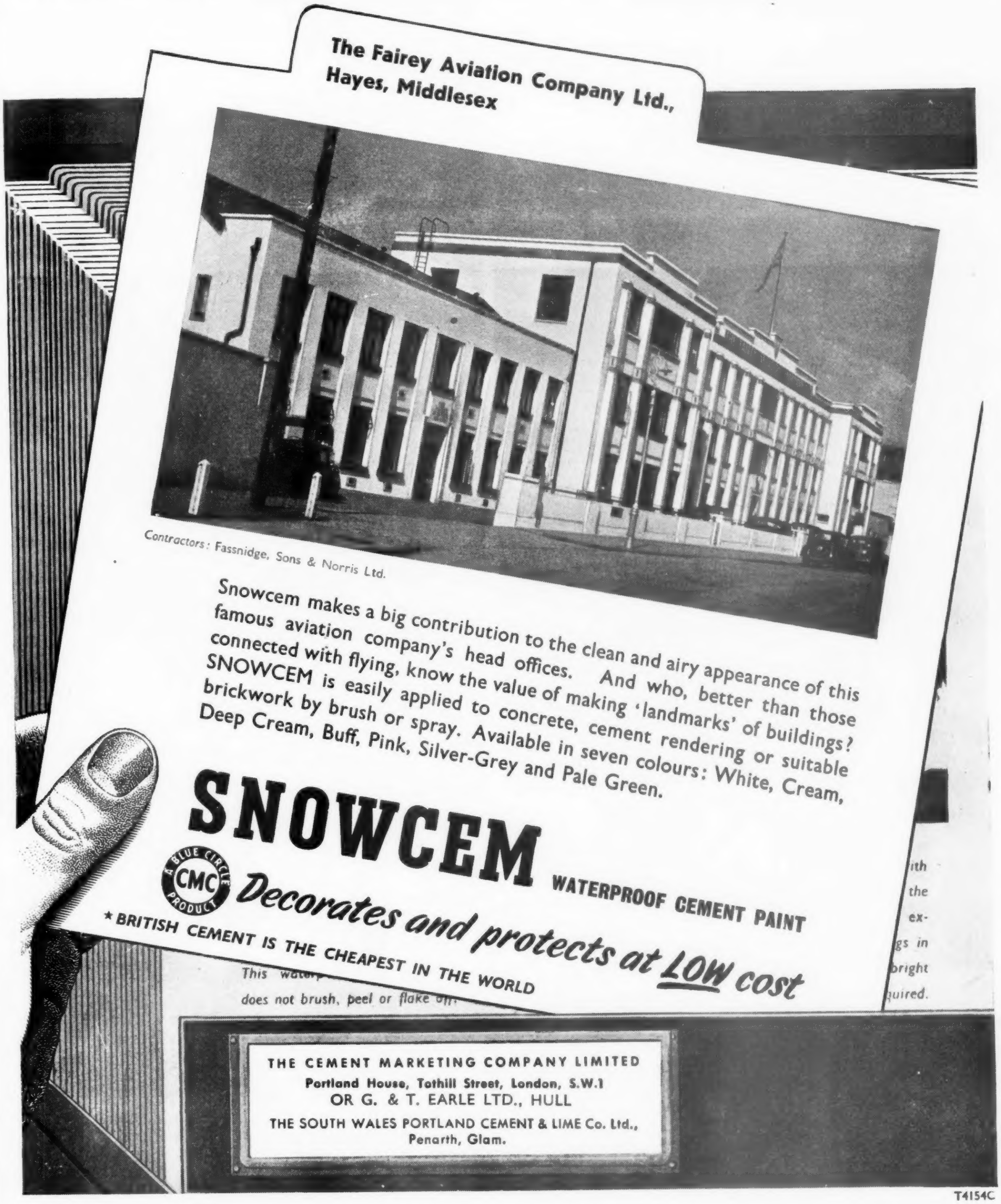

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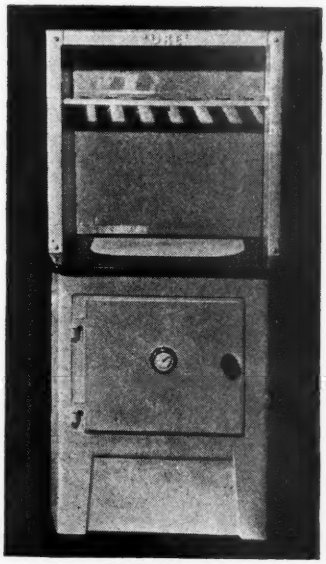

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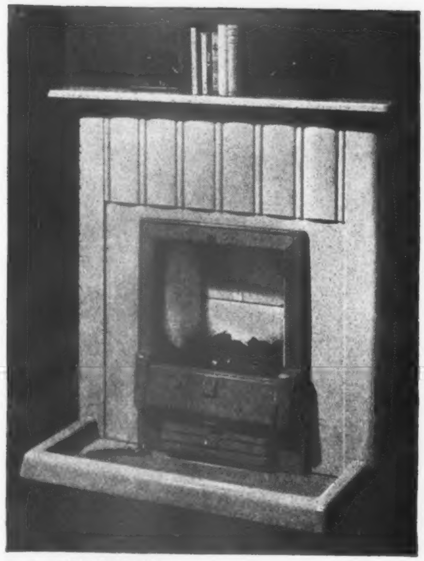

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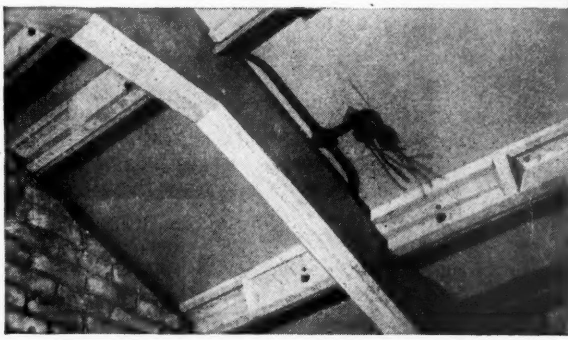

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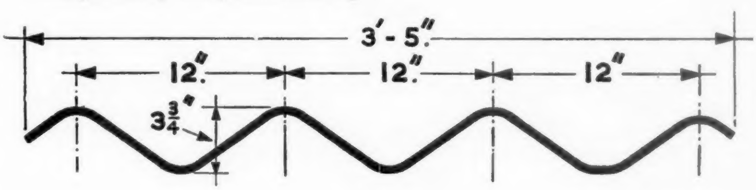

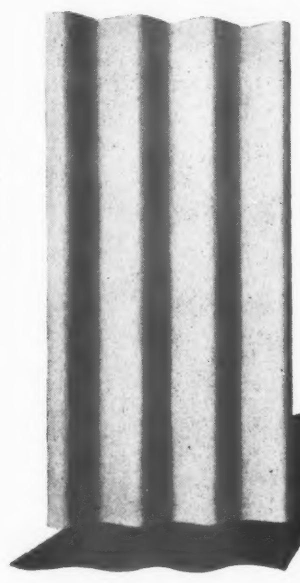

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Building Research Station Digest

No. 36 *(REVISED)*

SEPTEMBER 1954

Sound Absorbent Treatments

The surfaces of a room partly reflect and partly absorb sound falling upon them and the proportion either reflected or absorbed varies according to the nature of the surface of the material and the form of construction. In every case the proportion varies from one frequency or pitch of sound to another. Because sound travels relatively slowly, the result of this reflection is to create a reverberant body of sound which, merging with the initial sound, influences its character and often adds appreciably to the general " noise " level of a continuous source of sound. The quality of speech or music (especially the latter) is enhanced by a certain amount of overlapping reverberant sound, but too much results in confusion and loss of intelligibility or clarity. Distortion may also be caused by unequal reflection of the different frequency components. The period of sustained sound which follows the initial sounding of the source is known as the reverberation time; a suitable reverberation time according to the purpose of a room and its size has been broadly established by experience, and is recognised as an important factor in acoustical design. The reverberation time is determined by the total amount of absorption in a room in relation to its volume; it may vary from ½ sec. in an ordinary living room to 12 sec. or more in a large cathedral.

General use of Absorbents

For these reasons the selection of the surface finishes in a room and, if necessary, the application of special absorbent treatments to particular areas of surface is often of great importance, whether for ensuring intelligibility of speech or musical quality or for reducing the noise level. Absorbents also have their uses in certain problems of improving *sound insulation*, mainly by increasing the *attenuation* of the sound along certain paths; but a word of warning is not out of place here regarding a prevalent misconception that absorbent materials are sound insulating in the direct sense—that they substantially reduce transmission through them—which is not the case. This misunderstanding is to some extent natural because the term " sound-absorbing " leads to an expectation that the sound energy on passing into such a material is largely swallowed up and disappears. It is more helpful to a true appreciation if the conception of the term " absorbing " is limited to " non-reflecting ". That absorption is not a measure of insulation is forcibly illustrated by the extreme case of the open window, which (since it reflects no sound at all) is 100 per cent. absorbing but also virtually 100 per cent. transmitting.

Examples of the legitimate employment of absorbents for the improvement of sound insulation are absorbent linings or baffles in ventilation ducts (for attenuating sound along them), absorbent treatments in " cut-off " lobbies or corridors and, in special cases, absorbent materials or surfaces in the cavities of double-leaf construction; a notable example of the last application is the use of an absorbent lining to the reveals in double window construction. However, absorbent treatments are more generally employed either for the refinement of the sound quality in auditoria intended for music or for speech, or for the reduction of loudness levels in noisy rooms.

Treatment of Auditoria

In an auditorium, the total amount of absorption effected by the surfaces (furnishings and occupants included) should be adjusted so as to give a suitable reverberation time according to the size and use of the room.

Values of reverberation time appropriate to particular functions and sizes of room are given, usually by means of graphs, in many textbooks on architectural acoustics. Table 1 is a general guide to the range of optimum reverberation times sufficient for ordinary problems or for use during early stages of design.

Values are generally quoted (as in Table 1) for a medium frequency of 500 c/s; at higher frequencies the same reverberation time should be maintained if possible, though absorption by the air will tend to shorten it, especially in large rooms; at lower frequencies a gradual lengthening of the reverberation time is permissible, and may even be desirable, up to a maximum of 50 per cent longer at 100 c/s. When a compromise reverberation time is necessary, for a multi-purpose hall, the bias should generally be in favour of the shorter time; otherwise the clarity of speech may suffer.

Table 1—Range of optimum reverberation times, in seconds, at 500 cycles per second

Purpose or Type of Room	Size of Room		
	Small (under 25,000 cu. ft.	Medium (25,000 to 250,000 cu. ft.)	Large (over 250,000 cu. ft.)
Speech	$\frac{3}{4}$	4/5 to 1	1
School halls Multi-purpose halls Chamber music	1	1 to $1\frac{1}{4}$	1 to $1\frac{1}{2}$
Orchestral music Church organ music ...	$1\frac{1}{4}$ to $1\frac{1}{2}$	$1\frac{1}{2}$ to 2	$1\frac{3}{4}$ to 2 or more

Apart from the right amount of absorbent to secure an appropriate reverberation time, the correct placing of the absorbent areas is important. For instance, to prevent echoes (i.e., long-delay reflections, usually from a single surface) the back wall behind the audience should almost always be highly absorbent at all frequencies, and as a rule there should be an absorbent area on the side walls near the platform or stage end to prevent lateral echoes.

The junction between walls and ceiling is sometimes a danger point for echoes, because sound can be reflected out of an angle very effectively—the quick double reflection from the two surfaces being almost the equivalent of a single reflection from a flat surface. An absorbent margin should therefore be put along one surface of the junction wherever its position incurs a risk of echoes. The main part of the ceiling should generally be reflecting (unless it is very high) as this is a useful plane for rapid first reflections to strengthen the direct sound. Surfaces close behind the sound source, or splays on each side, should be reflecting for the same reason.

The intelligibility of speech is largely dependent on the preservation of the high frequency components. This does not mean that all absorption of these frequencies should be avoided, as this would give a long reverberation time in the upper register leading again to lack of clarity. The solution is to ensure maximum reflection of the upper frequencies by surfaces that will reinforce the direct sound with the shortest possible path difference. Smooth polished surfaces are required. Good direct sound is of course a basic requirement; as a general rule good sight lines result in good hearing.

Noise Reduction by Absorbents

The usefulness of absorbents for reducing noise varies considerably with the circumstances. To give a worth while reduction it is necessary as a rule at least to double the existing absorption, and this results in a noise reduction of about 3 db. This is usually a comparatively simple measure in rooms that are highly reverberant, but when there is already a lot of absorption, doubling it may be difficult or uneconomical. The maximum benefit from the treatment is obtained when the absorbent is placed as near to the source of noise as possible, so as to intercept the maximum arc of direct sound. When the noise source is a distributed one, the ceiling of the room is frequently the most useful area to treat; it is probably the largest single area available, is often reasonably close to the source, and in general it is more " exposed " to the direct sound rays than are most of the other surfaces.

Nevertheless, unless the ceiling is quite low, some absorbent should also be placed on the walls as sustained reflections may occur between hard parallel walls in spite of an absorbent ceiling. Any given area of absorbent treatment will function more efficiently if it is split up into a number of panels than if it is concentrated in one large panel.

The treatment will obviously be more effective if the absorbent material is most efficient in that part of the frequency range in which the greater part of the noise occurs. Certain machinery noises may have a marked pitch; most general noise, however, covers all frequencies fairly evenly, though there is usually some predominance of the middle or upper-middle frequencies.

In cases where the noise source extends over the whole of the room area, as in workshops full of noisy machines, less palpable benefit is obtained from absorbent treatments; the " listener " is likely to be so close to one of the sources of noise that the direct sound from it is dominant over the reverberant sound, and a reduction of the latter alone may result in but a slight " net " reduction of loudness. Nevertheless, a substantially reduced reverberation time may of itself be an advantage. Observation shows that

the resulting changed character of the sound usually reduces the factor of annoyance appreciably, perhaps mainly because an operative then hears his own machine with less confusion from surrounding noise. This is often one of the necessary conditions for lessening the strain of machine tasks.

TYPES OF ABSORBENT

Absorbents may be classified in three main types according to the manner in which they function, namely,

(*a*) porous materials,

(*b*) resonant panels,

(*c*) cavity resonators.

Type (*a*) absorb mainly at the higher frequencies, type (*b*) chiefly at the lower frequencies, whilst type (*c*) can be designed for maximum absorption at any point in the audio-frequency range. Many actual treatments are composite and function in more than one manner, and are thus made to absorb efficiently over a wider range. Increasing the thickness of any soft porous material increases the absorption at low and middle frequencies.

Examples of porous absorbents include mineral wool (slag wool or rock-wool), glass wool or glass silk, felts, wood-wool slabs, asbestos fibre spray, curtains or other soft furnishings, and proprietary drilled tiles of soft fibreboard or asbestos. Acoustic plasters are also of this type. The proprietary tiles usually have a surface which is more or less non-porous, but the drilled holes penetrate into the internal fibres; sound passing into the apertures is absorbed by the porous surfaces thus exposed. For this reason decoration which does not block the holes does not reduce the absorption materially. Porous plasters on the other hand may lose considerably by unsuitable decoration; even if the initial loss of efficiency is minimised by careful attention to the makers' instructions regarding decoration, subsequent repainting without supervision may seriously impair the absorbent properties.

Resonant panels individually tend to have a rather confined range of absorption about their " peak " or maximum point, which occurs at the resonant frequency. This frequency depends upon the weight of the panel and the depth of air space behind; the heavier the panel or the deeper the air space, the lower will be the resonant frequency. With common panel forms encountered in buildings the resonant frequency usually lies between 50 and 200 cycles per second. Sound pressure waves of appropriate frequency cause sympathetic vibration of the panel, and absorption is obtained when these vibrations are damped, partly by the enclosed air pocket behind. If some porous absorbent (such as mineral wool) is placed at the back of the panel in the air space, the damping action becomes greater and absorption is increased. The slight differences which inevitably occur in the form and fixing of apparently similar panels help to spread the absorption range, but it is useful in practice (since fairly level absorption at all frequencies is usually the aim) to widen the range still more by varying the construction of individual panels, employing different panel thicknesses, depths of air space, stiffening braces, etc. It should be borne in mind that fortuitous absorption at low frequencies is often obtained in buildings by panel forms of construction such as suspended ceilings or battened-out wall plastering. Even closed windows, although not backed by a confined air space, provide some absorption at the lower frequencies by their effect as panels.

A cavity resonator (often known as a Helmholtz resonator) is essentially a container with a small open neck; it functions by resonance of the air within the cavity. To increase its efficiency porous material is introduced into the neck. Efficient absorption is possible only over a narrow frequency band as, although any one resonator can be " tuned " to any frequency, the tuning is very sharp. Thus unless a large number, tuned to different frequencies, are used they are not suitable for reducing general reverberation time and their use is restricted mainly to the correction in auditoria of a specific acoustic fault associated with a single frequency. It might be thought that these resonators could be effectively employed in factories for overcoming annoyance from machinery having a sharply defined note, but in fact there is little point in such selective absorption by an expensive form of treatment when absorption at other frequencies also is no disadvantage and may be welcome.

Composite treatments

A class of absorbent treatment of comparatively recent development is composite in its nature and to some extent combines the function of all three types of absorbent. It consists of a perforated panel mounted over an air space containing a porous absorbent. The panel may be of plywood, hardboard, plaster-board, metal, etc., perforated with holes or with slots, and mounted on battens of suitable thickness; mineral wool or glass wool is commonly used for the porous absorbent, which for maximum efficiency should be situated close behind the perforated panel. An alternative form is a perforated board with an open textured material such as wood wool slab or grooved fibreboard (the grooves lining up with the rows of holes or slots) stuck to the back; the composite board is mounted on a batten framework, the wood wool or fibreboard acting as the porous absorbent. A perforated board with porous tissue paper stuck to the back also makes a useful absorbent when mounted on

battens; the filter action of the tissue paper damps the resilience of the enclosed air (a function normally performed by the porous material) but care must be taken when sticking it to the board that the adhesive does not flow across the holes and so seal the pores of the paper. All these perforated board treatments may be decorated with impunity provided the perforations are not blocked, even partially. A perforation area of at least 10 per cent. is desirable to allow reasonable absorption in the upper register, where this class of treatment tends otherwise to fall off in efficiency. These forms of absorbent treatment are proving a most valuable class in practice. They are durable, offer wide decorative scope and can be relatively cheap.

Reverberation time

From what has already been said it will be clear that whether a designer is concerned with the refinements of acoustic character or simply with noise reduction it is necessary for him to know the approximate reverberation time of the room. Given a knowledge of the absorbent properties of all the surfaces present this can be calculated with reasonable accuracy by the formula

$$T = \frac{0{\cdot}05V}{A}$$

where T is the reverberation time in seconds V is the volume of the room in cubic feet and A is the total absorption in the room (inclusive of furniture, occupants, etc.) in sq. ft. units. Sq. ft. units are known as Sabins, as are also the sq. metre units used on the Continent. The total absorption (A) at any frequency is obtained by multiplying the area (in sq. ft.) of each different type of surface finish by its absorption coefficient (i.e. the proportion of sound energy it absorbs) at the given frequency and adding these products together, adding on the absorption of occupants, articles of furniture, etc. An important contribution to the absorption at *high* frequencies only is made by the air within the room, and this should be added to the previous total at high frequencies. The total air absorption is, of course, its absorption per cu. ft. multiplied by the volume of the room (in cu. ft.). Calculations of the reverberation time should normally be made at representative frequencies for the low, middle and high frequency bands. These are usually taken as 125, 500 and 2,000 cycles per second respectively. Only in special cases is it considered necessary to calculate the reverberation time at other frequencies also. When a preliminary figure for one frequency only is required, it is customary to take the middle frequency of 500 c/s.

A list of approximate absorption coefficients at low, middle and high frequencies for various common building finishes is given in Table 2. The list was originally compiled by the Building Research Station for its own use, and being based on general field as well as laboratory measurements it has proved on the whole more applicable to average room and auditorium conditions than some of the previously published collections of figures probably gathered from isolated test measurements. For reverberant rooms of simple box shape with flat surfaces the figures given may however be somewhat high. A broad classification of absorption categories of the more effective absorbents is indicated in the Table, as follows:—

A ....General wide band absorption.

B ....Preferential absorption at middle and high frequencies.

C ....Preferential absorption at low frequencies.

Special items of importance in auditorium absorption are listed in Table 3. These lists are not of course exhaustive; proprietary treatments are too numerous and varied for inclusion, but figures for these can be obtained from the manufacturers. For preliminary guidance in the choice of special treatments, however, some graphs of the absorption characteristics of the different types of treatment discussed in this Digest are included; Fig. 1 gives absorption curves for some porous materials; Fig. 2 shows typical curves for panelling with and without absorbent in the air space ; Figs. 3 and 4 show the range of absorption of some perforated board treatments with varying degrees of perforation and depth of air space and with different types and thicknesses of porous material.

Some practical considerations

It is useful to remember that many materials (mineral wool, glass wool, wood-wool slab, fibreboard, etc.) which are good sound absorbents are also valuable for heat insulation. Therefore in some cases, as, for instance, single-storey workshops or factories, the cost of an absorbent ceiling treatment can often be justified on heat insulation grounds alone. Where appearance permits, simple roof linings of wood wool slab can be left exposed (i.e., unplastered, though decorated if desired), or rock wool, slag wool or glass wool blankets can be retained in place by acoustically transparent screens such as expanded aluminium lath of suitably small mesh. Asbestos spray is also useful for both sound absorption and heat insulation.

Objections are sometimes raised on the score that porous or perforated treatments are unhygienic or dust-collecting and often non-washable. This may be an important consideration in certain rooms in hospitals. It is not easy to meet the objection, except perhaps by accepting porous plaster with distemper decoration. Non-porous, washable treatments reasonably efficient as absorbents over a fairly wide frequency range are available, but they are expensive; examples are thick sponge rubber with a painted, impervious surface, and thick mineral wool blanket with a covering of leather-cloth or American cloth or some similar thin, flexible, non-porous membrane.

The question of fire risk sometimes arises because many of the materials used in the treatments are combustible and spread flame rapidly, and also because of the cavity behind wood, fibreboard or hardboard panelling, either perforated or imperforate. For the former, appropriate treatment by impregnation would be a safeguard but flame-retardant paints must not be used where the absorption characteristics would be affected. Filling the cavity entirely with mineral wool would reduce the hazard due to the cavity.

In conclusion, attention might again be drawn to the fact, already brought out in this Digest, that sound absorption is not an intrinsic property of a material alone. Factors such as thickness, method of mounting and decorative treatment are all of vital importance, and for this reason all absorption figures quoted herein should be regarded as average or representative rather than precise.

TABLE 2

COMMON BUILDING MATERIALS

No.	Material and method of fixing	Absorption Coefficients			Absorption Category
		Low Frequency 125 c/s	Medium Frequency 500 c/s	High Frequency 2000 c/s	
1	Boarded roof; underside of pitched slate or tile roof	0·15	0·1	0·1	
2	Boarding (" match ") about ¾″ thick over air space on solid wall	0·3	0·1	0·1	C
3	Brickwork—plain or painted	0·02	0·02	0·04	
4	Clinker (" breeze ") concrete—unplastered	0·2	0·6	0·5	B
5	Carpet (medium) on solid concrete floor ...	0·1	0·3	0·5	B
6	Carpet (medium) on joist or board and batten floor	0·2	0·3	0·5	B
7	Concrete, constructional or tooled stone or granolithic finish	0·01	0·02	0·02	
8	Cork slabs, wood blocks, linoleum or rubber flooring on solid floor (or wall)	0·05	0·05	0·1	
9	Curtains (medium fabrics) hung straight and close to wall	0·05	0·25	0·3	B
10	Curtains (medium fabrics) hung in folds or spaced away from wall	0·1	0·4	0·5	B
11	Felt, hair, 1″ thick, covered by perforated membrane (viz. muslin) on solid backing	0·1	0·7	0·8	B

TABLE 2 (*Cont'd.*)

COMMON BUILDING MATERIALS

No.	Material and method of fixing	Absorption Coefficients			Absorp-tion Category
		Low Frequency 125 c/s	Medium Frequency 500 c/s	High Frequency 2000 c/s	
12	Fibreboard (normal soft) ½″ thick mounted on solid backing	0·05	0·15	0·3	B
	Ditto, painted	0·05	0·1	0·15	
13	Fibreboard (normal soft) ½″ thick mounted over air space on solid backing or on joists or studs	0·3	0·3	0·3	A
	Ditto, painted	0·3	0·15	0·15	C
14	Floor tiles (hard) or "composition" flooring	0·03	0·03	0·05	
15	Glass; windows glazed with up to 32 oz. glass	0·3	0·1	0·05	C
16	Glass; ¼″ plate or thicker in large sheets ...	0·1	0·04	0·02	
17	Glass used as a wall finish (viz., "Vitrolite") or glazed tiles or polished marble fixed to wall	0·01	0·01	0·02	
18	Glass wool or mineral wool 1″ thick on solid backing	0·2	0·7	0·9	B
19	Glass wool or mineral wool 2″ thick on solid backing	0·3	0·8	0·75	A
20	Glass wool or mineral wool 1″ thick mounted over air space on solid backing	0·4	0·8	0·9	A
	Granolithic floor—see (7)				
	Lath and plaster—see (22) and (23)				
	Linoleum—see (8)				
	Marble—see (17)				
	Match boarding—see (2)				
21	Plaster, lime or gypsum on solid backing...	0·02	0·02	0·04	
22	Plaster, lime or gypsum on lath, over air space on solid backing, or on joists or studs including decorative fibrous plaster and plaster board	0·3	0·1	0·04	C

TABLE 2 (*Cont'd.*)

COMMON BUILDING MATERIALS

No.	Material and method of fixing	Absorption Coefficients			Absorption Category
		Low Frequency 125 c/s	Medium Frequency 500 c/s	High Frequency 2000 c/s	
23	Plaster, lime, gypsum or fibrous, normal suspended ceiling with large air space above	0·2	0·1	0·04	
24	Plywood mounted solidly	0·05	0·05	0·05	
25	Plywood panels mounted over air space on solid backing, or mounted on studs, without porous material in air space ...	0·3	0·15	0·1	C
	Ditto, with porous material in air space ...	0·4	0·15	0·1	C
	Rubber flooring—see (8)				
	Stone, polished—see (17)				
26	Water—as in swimming baths	0·01	0·01	0·02	
	Windows—see (15)				
	Wood block flooring—see (8)				
27	Wood boards on joists or battens	0·15	0·1	0·1	
28	Wood-wool slabs 1" thick (unplastered) solidly mounted	0·1	0·4	0·6	B
29	Wood-wool slabs 3" thick (unplastered) solidly mounted	0·2	0·8	0·8	B
30	Wood-wool slabs 1" thick (unplastered) mounted over ¾" air space on solid backing	0·15	0·6	0·6	B

TABLE 3

SPECIAL ITEMS

No.	ITEM	ABSORPTION UNITS (SABINS)		
		Low Frequency 125 c/s	Medium Frequency 500 c/s	High Frequency 2000 c/s
1	Air (per cu. ft.)	Nil	Nil	·003
2	Audience seated in fully upholstered seats (per person)	2·0	5·0	5·5
3	Audience seated in wooden or padded seats (per person)	1·7	4·3	4·7
4	Seats (unoccupied) fully upholstered (per seat)	1·3	3·0	3·4
5	Seats (unoccupied) wooden or padded or metal and canvas (per seat)	0·8	1·6	1·9
6	Theatre proscenium opening with average stage set (per sq. ft. of opening)	0·2	0·3	0·4

NOTE.—Audience or seating causes shading of the floor in auditoria and this should be allowed for in calculating reverberation times. Suitable adjustments of the *floor* absorption in consequence of this shading are suggested as follows:—

At 125 c/s.........reduce tabulated absorption by 20 per cent.
At 500 c/s......... „ „ „ „ 40 „ „
At 2000 c/s......... „ „ „ „ 60 „ „

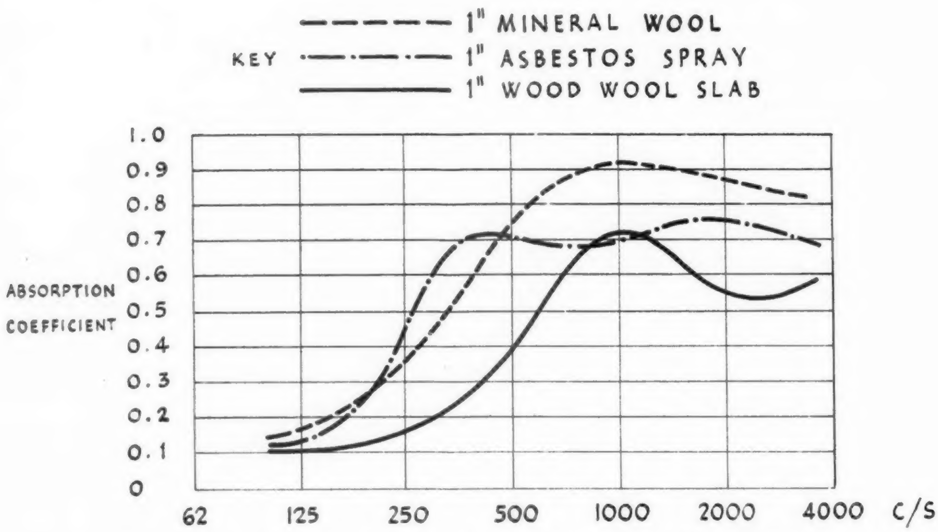

FIG. 1. ABSORPTION OF POROUS MATERIALS ON SOLID BACKING

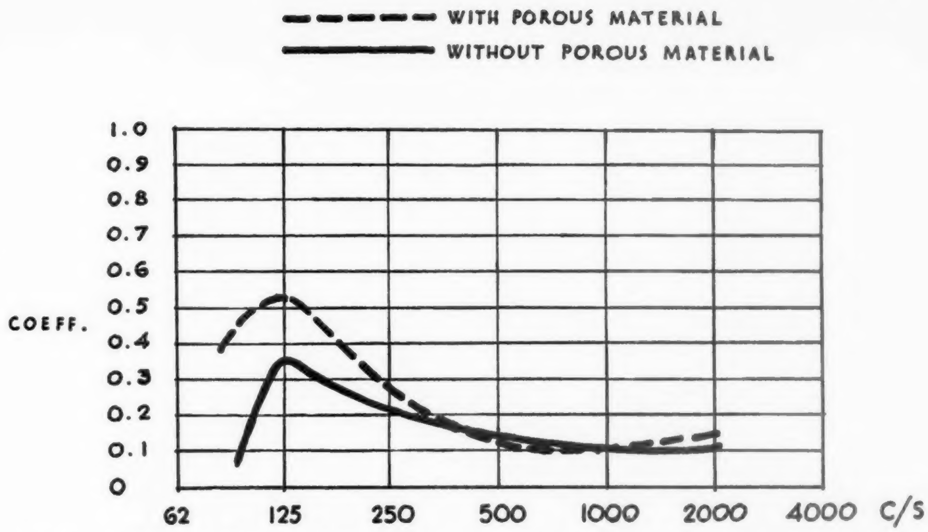

FIG. 2. ABSORPTION OF ⅜" PLYWOOD PANELS (with and without porous materials in air space)

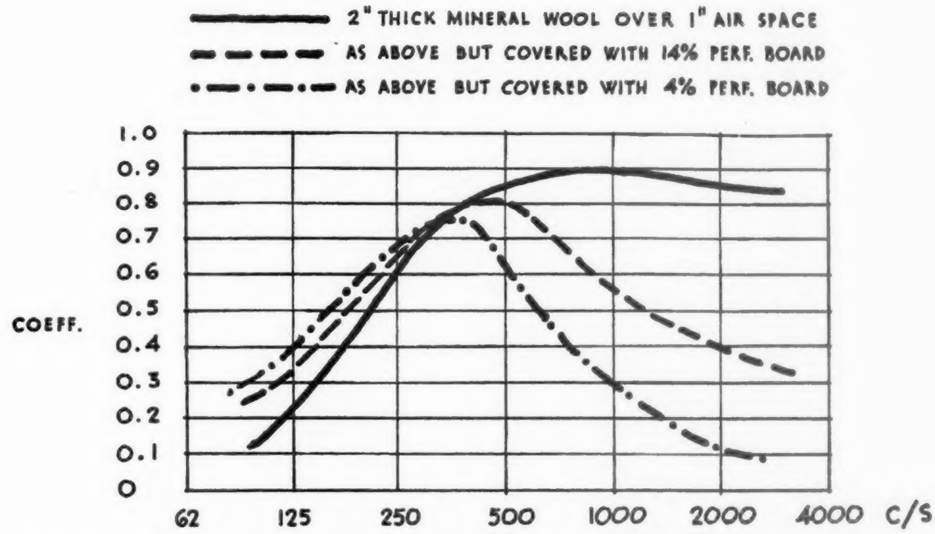

FIG. 3. EFFECT ON HIGH FREQUENCY ABSORPTION OF COVERS OF PERFORATED BOARD OF DIFFERENT PERCENTAGE PERFORATION

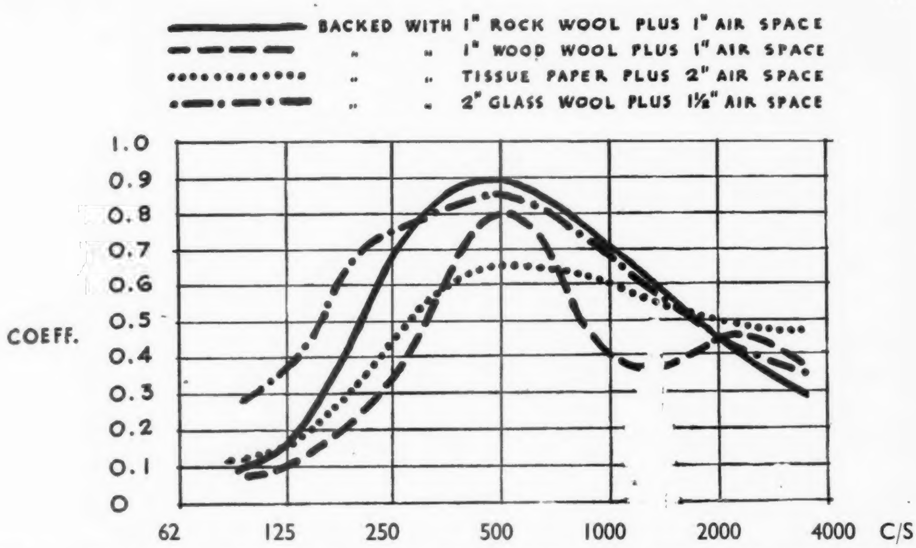

FIG. 4. ABSORPTION OF PERFORATED PLASTERBOARD (12% PERF.) ON BATTENS WITH DIFFERENT POROUS BACKING MATERIALS IN AIR SPACE

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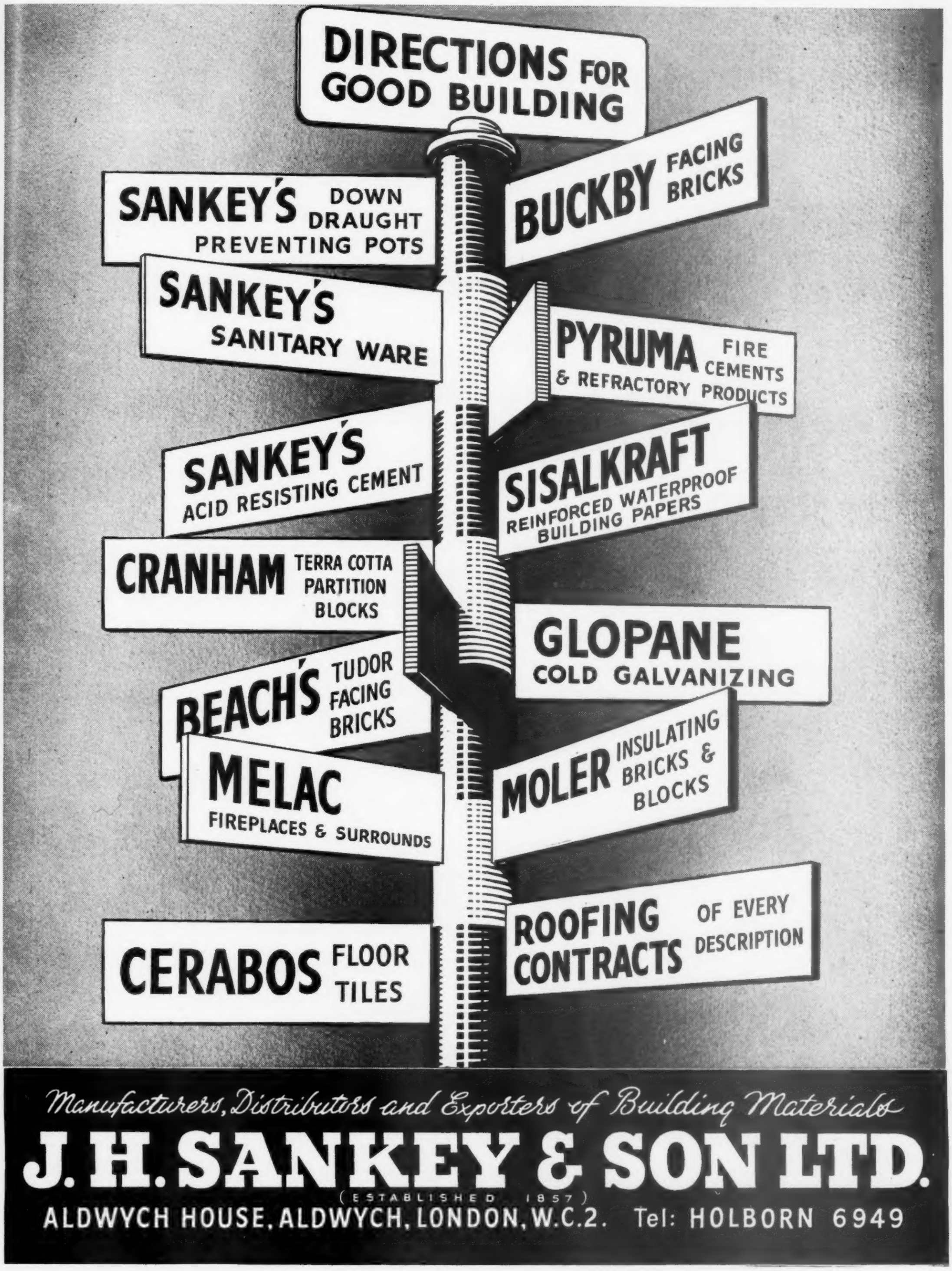
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